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IMPROVED OIL ENGINES.

AMONG the oil engines entered for trial at the forthcoming Royal Agricultural Society's Show at Cambridge, are two constructed by Messrs. Richard Hornsby & Co., Limited, of Grantham, for the illustrations of which and the following particulars we are indebted to *Engineering*. Fig. 1 is a standard pattern of a fixed engine of 8 brake horse power, and Fig. 2 is a portable engine of 12½ brake horse power. We have on several occasions laid before our readers the distinctive features of these engines, and need only deal briefly with them now. It is, perhaps, easiest to describe them by negatives. There is no air pump, no spray maker, no incandescent tube, and no electrical apparatus. The absence of these features evidently implies great simplicity of construction and the possibility of placing the engines in the hands of men of small mechanical ability. The oil is supplied to the vaporizer, which is in direct connection with the cylinder, by a pump, which delivers it immediately before the crank passes the center at the commencement of its acting stroke. The heat of the vaporizer causes the charge to flash into flame, without any separate igniting appliance, and this heat is maintained by the fact that each explosion commences in the vaporizer, and thus keeps it at a temperature approaching a dull red. The oil pump has ball valves, both sets—suction and delivery—being in duplicate to insure certainty of action. At the commencement of the day's work the vaporizer is heated for a few minutes by a simple lamp, and after that the engine requires no further external heating.

The engine works on the Beau de Rochas or four cycle system. The air and exhaust valves are arranged on one side, and can very readily be got at. The governor is of the Porter type, and regulates the oil that the pump supplies by opening a valve which allows the surplus oil to return. Both the engines illustrated run at the very moderate speed of 200 revolutions per minute. These engines will use almost any class of oil of a specific gravity of 0·8 to 0·9, and a flashing point up to 325 degrees. They are made in sizes from 1½ to 25 brake horse power.

In the portable engine a simply arranged cooling tank is placed in the front, the water being pumped through the cylinder jacket and then allowed to run through the cooler; the exhaust from the cylinder acting up the chimney causes a current of air to be drawn through the cooler, and thus cool the water. The engine is mounted on a wrought iron frame and wrought iron wheels, so as to give great strength and at the same time lightness.

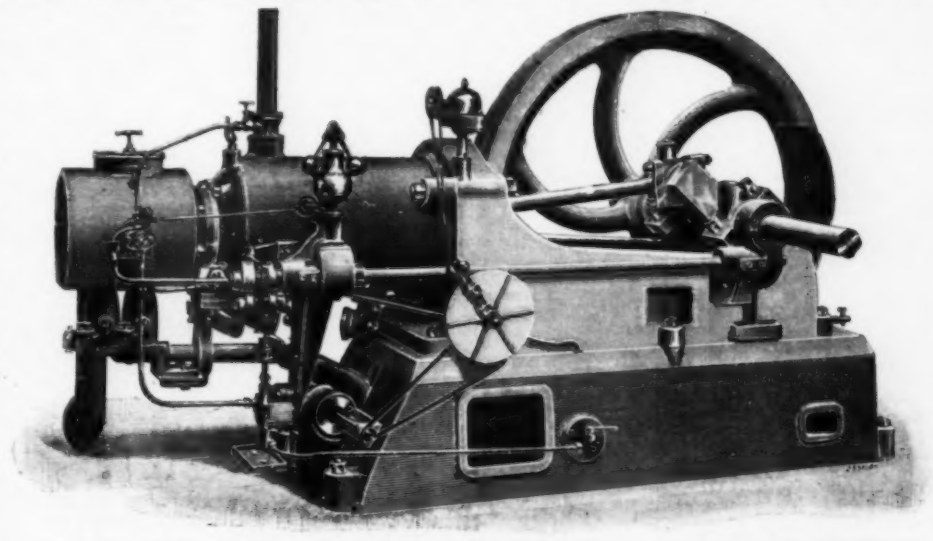


FIG. 1.

FIG. 2.

IMPROVED OIL ENGINE.

LIQUID FUEL.*

By G. STOCKFLETH.

DURING last year's coal strike the question of using liquid fuel as a substitute for coal for generating steam was much discussed, and has since been in more than one sense a burning question. A few words on the subject may therefore be of interest.

The use of liquid fuel is by no means of recent date, it has for many years been pretty general in Russia, and the question cannot any more be considered as a problem which has to pass through its experimental stages. Before going further into the subject, it may be well to define which liquids can best be used as fuel. A good many oils might enter the list were it not for some indispensable requirements, such as cheapness, absence of danger, capability for developing heat and undergoing complete combustion, without producing unpleasant smells, smoke, and dangerous and unhealthy gases, which conditions practically reduce the number to the oils derived from coal and from crude petroleum. The first named (oil derived from coal) is, however, not produced in sufficient quantities for even a limited consumption, and would be far too expensive to manufacture solely for fuel purposes. It is, therefore, to crude petroleum that we must turn for obtaining a suitable oil.

Crude petroleum consists almost entirely of a mixture of a great number of hydrocarbons differing in boiling point and density, and, by being submitted to distillation, it gives a series of hydrocarbons known as gasoline, benzoline, kerosene, etc. It is not necessary here to give a detailed description of these different products; suffice it to say, that the first distillate of crude petroleum, which evaporates at a low temperature, is the most inflammable, and gradually, as the temperature is raised, the less dangerous oils are distilled, until the temperature in the stills reaches 300° C. to 320° C.; at this point the distillate is called kerosene, and the residue (which in Russian is called astatki) forms the oil which so admirably answers the conditions for a good liquid fuel. It contains all the heavy hydrocarbons capable of creating heat, and the high temperature to which it has been exposed having freed it from all dangerous volatile liquids, guarantees its complete safety; a match or any other naked light is immediately extinguished when plunged into it. In order to make it burn it requires special treatment, about which more shall be said presently. As astatki presents no danger whatever, it is in Baku stored in large open excavations in the ground, containing up to 5,000,000 poods each, equal to more than 100,000 tons. In some of the distilleries astatki is used as fuel under one still immediately after having been let out of another, which shows that even at a high temperature it can be handled with safety. The Russian crude petroleum gives about 35 per cent. benzoline, gasolene, and kerosene; the remaining 65 per cent. is used for the manufacture of lubricating oils and mostly as fuel. To give an idea of the extent to which it is used in Russia for locomotive, steamship, and even stationary boilers, it may be mentioned that the transport of astatki from Baku to the Caspian seaports and Astrakan amounted in 1892 to 107,361,435 poods, equal to about 3,000,000 tons; and, in addition to this, some 250,000 tons were shipped from Batoum. The statistics for 1893 are not yet available for reference, but will probably show an increase.

In the above mentioned tonnage the consumption in Baku, which amounts to more than 100,000 tons yearly, is not included. Astatki is the only fuel used at the boring of the wells, and for all distilling purposes, in some cases even for domestic use in warming and cooking stoves. The consumption in this latter way is of course insignificant, but may be mentioned as showing the possibility of using it for this purpose. The arrangement is as follows: A tank is placed somewhere on the top of the house, and a system of half inch pipe leads the oil to the different stoves, where it is allowed to drip on to a small cast iron disk or plate, placed in front of the stove door, which is provided with a small opening creating a strong draught; when once the plate is warm and the dripping of the oil is properly regulated, it burns without further attention.

For boiler and distilling purposes it is necessary to create a more powerful flame, and steam is used for forming a spray which is easily ignited and burns fiercely. Many injectors or pulverizators in Russia, called fasunkas, have been constructed and patented, but it has been found that the most primitively constructed pulverizators answer as well as the more complicated kinds. The apparatus used under the stills consists simply of two half-inch pipes, one leading the oil from the tank, the other steam from a boiler. The ends of the pipes are flattened by a blow of a hammer, and then tied together with a piece of wire; the steam jet catches the outflowing oil and forms the spray. It is well to keep the oil a little warm to facilitate its passage in the pipes through which it descends by

* Recently read before the Society of Arts, London. From the *Journal*.

gravitation. This pulverizator gives entire satisfaction; the flame is powerful and bright, and not a drop of oil is wasted when once the flow has been regulated. No smoke or flame ascends the chimney—which, by the way, can be very short—as the steam jet itself creates sufficient draught. A somewhat neater appearance can be given to the injector when the oil pipe is arranged inside the steam pipe, and provided with a cast iron or brass nozzle which can be shaped to give the flame any desired form. As far back as 1890 I had occasion to make, on behalf of Messrs. Nobel Brothers, in St. Petersburg, some experiments with oil firing before a committee of the Russian Admiralty. At that time astatki firing was a novelty. The object was to demonstrate its practicability for firing marine boilers. The pulverizator was of a somewhat complicated construction. The results were, however, satisfactory; the boiler used belonged to a steam launch.

Experiments have been made with compressed air for spraying the oil, but the results have not materially differed from those obtained with steam. Air must, of course, in any case, have access to the flame, and openings on the front of the flue must be provided for its admittance. In most cases the hole in the furnace door through which the nozzle of the pulverizator is introduced is sufficient for letting in the quantity necessary for the combustion. The action of the steam is therefore solely mechanical, and serves only for cutting up the oil in small particles, which being surrounded by the necessary air for their combustion, catch fire before they reach the bottom of the flue. By using steam for spraying, no oil accumulates in the flue when the flow is regulated, consequently a complete combustion of the oil takes place. If better results should be obtainable by using compressed air for spraying, the reason would have to be looked for in some chemical effect of the steam upon the oil which, to some extent, could deprive the latter of its heat-creating properties. There is, however, no probability for this anticipation; if the steam had this effect, it would already have done its work in the still, where superheated steam is admitted into the crude oil to facilitate the distillation of the different crude oil products. Looking at the question from the point of cost, it is not probable that the compressed air can be produced cheaper than the necessary quantity of steam taken direct from the boiler. It is, in fact, but a very small quantity which is necessary for doing this work, when the pulverizator is properly constructed; and no case has come to my knowledge in Russia where the adoption of liquid fuel has augmented the quantities of feed water used in a perceptible degree. The chief point in the construction of the pulverizator is to avoid waste of steam, that is to say, to construct the nozzle in such manner that every particle of steam takes care of a corresponding particle of oil. This object will best be secured when the openings for the steam, as well as for the oil, are made long and narrow, and are placed as close to one another as possible. All the different Russian constructions are made in this way. The openings are about 1¼ inch long and ¼ inch to ⅛ inch wide. As the oil sometimes contains paraffin, which is likely to choke this narrow opening, it is essential to have an arrangement by which steam can be led through the oil passage to clean it out. The rest of the construction may be varied to suit particular cases, and with a view to facilitate and cheapen the manufacture.

At the present time a great many ships on the Black Sea, and all steamers on the Caspian Sea, as well as all locomotives in Southern Russia, burn astatki. The general advantages obtained by using liquid fuel in any boiler, whether stationary, locomotive, or marine, are the following: It can be adapted to any construction of boiler without material change in the existing arrangement for firing with coal; in fact, coal and oil can be used alternatively if so desired. The fire bars have simply to be taken out or covered with thin slabs and cinders. The furnace door has to be provided with a hole for introducing the nozzle of the pulverizator, and the steam pipe and oil pipe have to be connected respectively with the boiler and the oil tank. The steam-generating power of astatki is considerable; one ton of oil is, in this respect, equal to more than two tons of best steam coal, and is often claimed to be equal even to three tons of coal; it depends, of course, upon the quality of oil and coal used for the comparison. The fire can be extinguished instantaneously, and is absolutely free from smoke or ashes. The frequent opening of the furnace doors can be avoided, thus saving heat and preventing leakage of tubes, due to currents of cold air. Rapidity in raising steam and complete control over the fire are secured, thus avoiding waste of steam by the safety valves, and the boiler pressure can be regulated better than in the case of coal firing. After mentioning these general advantages, a few words may be added about the special advantages accruing to railways and steamships. The valuable spaces at railway stations, which have now to be sacrificed for accommodating coal supply, could be reduced by about two-thirds, as only half the tonnage would have to be kept in stock, and this quantity can be stored more economically in point of space than the same quantity of coal. A considerable amount of labor employed in storing coal and loading tenders can be saved, and the oil can be taken in simultaneously with the water supply, as quickly and in a like manner. The avoidance of smoke and blowing safety valves will greatly add to the comfort of the passengers, a point for which the railway companies are usually prepared to make considerable sacrifices.

The hard work of the stoker on an express train is reduced, as far as firing goes, to simply giving the regulating valve of the injector a turn from time to time, and the absence of dirt and smoke makes the service less disagreeable than with coal firing.

For steamships the advantages of using liquid fuel are of still greater importance. Much valuable space which has to be sacrificed for coal bunkers can be saved; the oil can be kept in ballast tanks at the bottom of the ship, an arrangement which greatly augments the stability of the vessel, and the oil can gradually, as it is consumed, be replaced by water. The size of the stoke hold can be reduced considerably, and the number of stokers diminished in the proportion of one to four. In stormy weather, and in case water should gain access to the stoke hold and put the fire out, it is considerably more troublesome, and takes more time to relight a coal fire than to restart the oil fire, and the risk of accidents by scalding is diminished. The danger of fire in the coal bunkers will not be replaced by any similar risk connected with the use of oil. Lastly, it may be mentioned that a ship having oil at its disposal may, by pouring a certain quantity overboard in stormy weather, avoid much trouble. For torpedo boats the use of liquid fuel is possibly of still greater importance than for any other vessels; the entire absence of smoke will help to avoid detection and possibly destruction, and the saving in space is of the utmost importance, as well as the possibility of raising steam quickly. The last years have seen a complete revolution in boiler making. Water tube boilers seem to be the type of boiler for the future. Various constructions are in the market, and a keen competition is going on for the best designs. Without going into details, it may be mentioned that the principal merits claimed are reduction of size and rapidity in raising steam of high pressure. Oil firing greatly furthers these ends; fire grate and ash pit can be done away with altogether, the length of the funnel can be reduced, and a system of water tubes is better suited to the fierce fire of liquid fuel than the straight or curved surface of an ordinary thick boiler plate. No boiler specially designed for liquid fuel is yet in the market, but the subject leaves certainly a wide field open for the boiler designer who, with liquid fuel, can obtain a flame which can be controlled, directed, and given uniformity much better than a coal fire, and which is less dependent upon air currents.

Besides serving as a combustible, there are many minor outlets for the sale of astatki. It forms an excellent lubricant as it is, and by mixing it with other substances, several lubricants of a higher class can easily be created without submitting it to further distillation. A very good and durable paint of various colors can also be made with it. Brick-built dwelling houses have been painted with astatki to avoid moist and damp walls, and it answered very well.

A disposition to use liquid fuel has already been shown in this country, both for locomotives and steamships. A certain number of locomotives, and even stationary boilers, have been fitted to use oil, and have burned the tar oil which was obtainable. A small quantity also of astatki which had been shipped to this country has been employed for steamship use.

Now the question arises, Can this combustible be obtained in sufficient quantities and at a cost which will secure a general use of it? As regards cost, it is evident that the best market can be expected in countries where coal is expensive and where oil can be got cheaply; it is, therefore, not at present very probable that this fuel will be adopted to any considerable extent in this coal-producing country, with its annual output of 185,000,000 tons. But in parts within the British dominions and elsewhere where oil is found on the spot, and where coal is expensive, especially in tropical climates which are detrimental to the quality of coal, very good markets could certainly be created. Up to the present time, oil fields have generally been looked upon as sources for lamp oil only; the principal question has always been to obtain oil capable of yielding a high percentage of this commodity, and the residue has been considered as more or less valueless. There exist, however, places where heavy oil not capable of yielding more than say 20 per cent. of kerosene could be sold as liquid fuel at a very large profit, and I propose in the following to say a few words about the work as well as about the yet unexplored oil fields which may be looked forward to as sources of supply.

SUPPLY.

America and Russia produce very different classes of crude oil. The American oil gives about 80 per cent. of kerosene, and the remainder is partly utilized for making other petroleum products. There is, therefore, no likelihood of getting any great supply from these fields. The Russian crude oil, on the other hand, only gives about 35 per cent. of kerosene and other products, leaving 65 per cent. of astatki for fuel; there are therefore, if not unlimited, at least very considerable quantities at hand from these fields.

At present, no oil territories which approach the American or Russian in magnitude are worked, and how far such enormous quantities of petroleum will ever be found anywhere else is difficult to form an opinion about; all that can be said is that several places in different parts of the world present quite as good indications of the presence of oil as the others did before they were worked. Nothing but actual boring can give full certainty about the importance of any particular oil field, and even the boring of a very limited number of holes, which may have proved to be dry holes, are not absolutely conclusive. Here, again, the Russian fields furnish a good example; the first borings were made at a place called Surachaney, where the escaping gases seemed to indicate a most probable presence of oil, but the borings yielded none, or but little, whereas not more than two miles away from this place, the Sabuntchy fields have produced the enormous fountains, the magnitude of which has been so astonishing, and it is there that the pumping, or rather bailing, wells are now in full exploitation, so to say, side by side, the average distance from one to the other being only one hundred yards.

In regard to other existing sources of supply, the later years have seen important oil industries carried on in Burma, Canada, Galicia, Sumatra, Java, Japan and Peru. At some of these places the oil is of a quality more like the American than the Russian, and produces principally kerosene, leaving but a small percentage available for fuel. At others it is heavier, as in Java and Peru, in which latter place liquid fuel has been adopted by several railways for their locomotives and some steamships are also run with it.

The last year's general depression in trade and enterprise, and the cheapness of petroleum from American and Russian sources, have, to a great extent, checked further development of oil fields, but with a general revival of trade and higher petroleum prices, there is a great probability of enterprise being directed to the many yet undeveloped fields which at present exist, and of which several are situated within British territory. It may, therefore, be suitable briefly to mention the most important which are likely to be exploited or further developed, and to offer a few remarks on the work in connection with such development.

To begin with the fields within the British dominion, the oil fields of Burma have yielded a considerable quantity of oil, and large areas not yet exploited are reported to present good indications for further operations. An extensive oil industry in that part of the world would be of enormous importance, both as a source for lamp oil and fuel; some of these fields are situated in proximity to the sea, which greatly enhances their value.

Several islands in the West Indies give also very good indications of oil, the most remarkable being the extensive pitch lakes in Trinidad, which seem to warrant the presence in deeper strata of heavy oils, exceedingly suitable for giving liquid fuel. Canada has also in late years developed an extensive oil industry, but the petroleum there is more like the American, and gives but little residue.

Outside British dominion, Mexico may be mentioned as a source for oil. Numerous indications are present, both on the Pacific coast side and on the Gulf side, and borings are now going on there.

BORING.

Boring for oil may be said to date from 1859, when Colonel E. L. Drake bored the first well in Pennsylvania, since which more than 60,000 wells have been drilled in Pennsylvania and adjoining States. In Russia, boring operations commenced 20 years later, and the number of wells drilled is considerably less, but they have been more productive than the American. On account of the different geological formations of these two countries, the modes of boring are different, as well as the form of the wells. In America, a well is often drilled through rock from top to bottom; the average diameter is 8 inches at the top, and the depth is about 2,500 feet. A complete outfit for drilling such a well costs $10,000, and the wages of the drillers are three to four dollars a day. If drillers are secured for work outside the United States, they receive $125 a month and traveling expenses.

In Russia, a well is 20 inches to 24 inches in diameter at the top, and has a depth of about 800 feet. The boring mostly is made by contract, and the total cost of a well may be put at 30 000 rubles or £3,000. When a new territory has to be taken in hand, it is, however, a mistake to start with securing such costly drilling outfit, the use of which only can be justified when the development has reached a more advanced state, and when it has been ascertained what strata have to be dealt with, and some arrangement has been made for transport and repair of heavy outfit.

The safest and most practical way to proceed will, in most cases, prove to be the following: After thorough surveying of the particular field by competent experts and geologists, and after having located a number of places suitable for trial borings, the necessary plant has to be brought into operation, not so much with a view of getting hold of the largest quantity of oil for the storage of which no provision has usually been made, but for ascertaining the depth at which the oil will be struck, and as a guide in defining the extent of the oil-bearing strata. For this purpose it is not necessary to go beyond a depth of say 1,000 feet. If the strata met with, and which have to be carefully recorded, do not give satisfactory results, another place has to be tried, and so on, until the operators have thoroughly sounded the ground, and are perfectly convinced that plant for larger and deeper wells is justified. The cost of plant, the amount of skill required in the operations, and the time employed progress at a much quicker ratio than the depth; in other words, a 3,000 feet boring costs more in money and skill than, say, five borings 1,000 feet each; and a territory is much better tested by 20 borings of 500 feet than by five borings of 2,000 feet. If oil is found only at 3,000 feet in a new territory, it does not, in fact, present very encouraging prospects, unless, of course, the quantities found should be found to be very considerable; but, as a rule, and very naturally, the level of the oil lowers when a territory is tapped, and it may soon prove more or less valueless on account of the costly deep drilling not being justified by the output. To give any hard and fast rule for the depths to which it is worth while to drill in a new field depends naturally on many circumstances which have to be taken into account in each particular case, the prices to be obtained for the oil, the geographical position of the place, and so on. In some cases not only heavy drilling plant, but storage tanks, and even refineries have been put up before the quantity of oil found or likely to be found was ascertained. Such proceedings cannot, of course, be justified. Supposing abundance of oil is suddenly found, that a well or even a fountain is struck at 45 feet, as has been the case at Baku, the wisest thing to do is to let it flow or try to plug the well. Precautions must then be taken that a similar occurrence is provided for a second time, and excavations in the ground properly lined, or iron or wooden tanks may be held in readiness.

To indicate a fixed sum which will prove sufficient for test work in all cases is, of course, not possible; but a drilling plant for a 4 foot test hole, 500 feet deep, with necessary casing complete, for hand work, can be had for £350. By hand the work, however, progresses somewhat slowly, and in most cases it may be advisable to use steam power, which can be secured for an additional sum of £125.

The system to be recommended for such borings is the ordinary artesian well boring, with rods and ropes and portable derrick; for later borings a fixed rig iron and wood for use of the American and Canadian boring system and heavier tools may be adopted. One outfit for every two, three, or even four test holes may be sufficient, and requires but one experienced man with two unskilled helpers for its manipulation. If steam power is used, an additional man will be required. Responsible technical supervision of the operations is, of course, indispensable in any case.

In the foregoing I have tried to point out which oil forms the best material for liquid fuel, to describe its manufacture, its absence of danger, and the manner in which it is burned for different heating purposes. I have also endeavored to draw attention to the many yet undeveloped fields from which it can be obtained, and, lastly, to indicate briefly the manner in which the preliminary exploration of new fields has to be carried out, in order to minimize expenditure, before sufficient certainty of success has been ascertained. As already mentioned, a more

general adoption of liquid fuel will greatly increase the value of the oil fields, especially of those which yield a product more or less unsuitable for the manufacture of lamp oil, and it is to be hoped that these fields will, in the future, receive the attention they deserve.

DISCUSSION.

The chairman (Boverton Redwood, F.C.S.) said that having traveled in steamships and on railway trains fired with liquid fuel, he could fully confirm what had been said as to the advantages of that description of fuel. In the stokehold of a ship where solid fuel was employed there was a little army of grimy perspiring coal trimmers and stokers, and their work was very trying in tropical climates, and often caused death or serious illness; but where liquid fuel was used all that was necessary was to regulate the valves from time to time; and he had been on steamers of considerable size where a single attendant did all the work, and then was able to spend a great part of his time in reading the paper. Having already said something as to the leading part taken by Russia in the development of liquid fuel, it was only right to add that at an earlier period a good deal of attention was paid to the subject in this country. In 1830, the use of hydrocarbons for raising steam was advocated by Pinkus; in 1864, a number of trials were made at Woolwich with an apparatus invented by Richardson, and in the same year the apparatus of Bridges Adams was tried experimentally. In 1868 the government tried a system invented by Wise, Field and Aydon, which about that time was put into practical operation at the works of Messrs. J. C. & J. Field, the candle manufacturers. In the same year an apparatus invented by Crowe was tried by the Admiralty, and about the same time a successful trial was made with a vessel of about 500 tons, the Retriever. About 1862 considerable attention was devoted to the subject in the United States, and large numbers of patents were taken out for apparatus for burning liquid fuel. In 1870, he believed the first steamship was fitted up in Russia on this system. Again in England in 1886, the Tarbutt and Quentin system of burning liquid fuel was put in practical operation. It would appear, therefore, that the practical supremacy of Russia had been largely due to the fact of her possessing such large supplies of necessary material, but it was worthy of note that although in America there were enormous supplies of oil, attention was not directed to the substitution of liquid for solid fuel until long after it had become an established fact in Russia. In Argentina liquid fuel was adopted on one of the railways in 1890, and there were twelve locomotives burning it. In Peru also there was a large and increasing demand for it, and anywhere along the coast where supplies could be obtained at a reasonable cost there was no difficulty in selling practically any quantity. Within the last few months the Baku Standard, a petroleum tank steamship, had been driven across the Atlantic by liquid fuel, and this again marked an important epoch. Unfortunately she had by no means a favorable passage; she encountered icebergs and head winds, and stormy weather, so that her voyage was a long one, but the fact of having crossed the ocean successfully notwithstanding these difficulties was perhaps a better test than if she had had fair weather. Again, Mr. Holden, of the Great Eastern Railway, had devoted a great deal of attention to the utilization of liquid fuel, and for a long time had had a number of locomotives at work fired in that way. In the United States during recent years there had been a great increase in the employment of liquid fuel for purposes other than steam raising, and, in glass works particularly, he understood it was found to give very satisfactory results. It was with some disappointment that he heard what Mr. Stockfleth said as to the burners employed; a large number of patents had been taken out for appliances of this kind, and it was a pity that the amount of mental labor devoted to this ma ter should not have resulted in the attainment of commensurate results. It might be, however, that though the comparatively primitive burners gave perfect satisfaction in Russia, that might arise from the abundance of the material, which obviated the necessity of great economy in its use, and that if they were subjected to critical comparative trials, other burners would be found superior. But apart from the question of economy, there were other points to be considered in judging of the relative value of these burners. The question of noise was of some importance, as he had sometimes found that this noise from an ordinary Russian pulverizator was, to a certain extent, a nuisance, and that some burners were more noisy than others. Again, certain burners required more steam in relation to the work they were doing than others, and this was a point of great importance, for one obstacle in the way of introducing liquid fuel on steamships had been the difficulty of making up for the loss of steam required in the pulverizing of the oil, and in some cases it had been suggested that it would be necessary to have an auxiliary distilling apparatus, to supply to the boiler, in the shape of condensed water, an amount equivalent to that used by the pulverizator. There was also a great difference in some of these burners in the character of the flame; some gave a flame of the blowpipe character, a long, pointed flame, which was liable to do considerable damage to the boiler plates if allowed to impinge on them. With regard to the economy of liquid fuel, as compared with coal, it had been pointed out that we had not as yet any boilers specially designed for the use of this fuel, so that they did not yet know what was the real thermal efficiency of liquid fuel as compared with coal. In some cases double the efficiency had been obtained, and in others three times had been claimed, while Admiral Selwyn asserted that the superiority was much greater still. The question of supply was of great importance, and in this country the price stood in the way of any extended use of liquid fuel. In a recent number of the *Shipping Gazette* it was stated that experiments with liquid fuel on one of the steamers on the Clyde were being discontinued, because the oil employed had risen so much in price that it was found more expensive than coal. Unfortunately, up to now, users and producers had waited for each other, and it seemed to him that there ought to be a little more courage on the part of those who had valuable sources of supply in developing them. There was too much disposition to wait until they were assured of a demand for so many thousand tons per annum; while on the other hand, those who might be inclined to use this material, said they could not be expected to make arrangements to use it until they were assured of a constant supply at a certain price. The result was there had been almost entire stagnation. It also seemed to him that, even if oil were more costly than coal, there were cases in which it would be desirable to use it, as, for instance, on the Underground Railway, for the sake of avoiding sulphurous fumes, and in electric lighting stations in London, where there would be a great saving of space in storage, fewer vehicles would be required to transport it, there would be no ash or clinker to remove, and the amount of steam required could be increased much more readily to meet certain emergencies, such as a heavy fog. There were so many purposes to which petroleum could be applied, including the manufacture of gas for illuminating purposes, that he thought the future historian would very likely regard this as the age of petroleum.

Mr. Nelson Boyd said the calorific value of the petroleum, taking it on the average to contain 85 per cent. carbon and 15 per cent. hydrogen, would work out at about 20,000 units, compared with 14,000 for coal, but the results obtained in practical working were much larger. That arose from several causes. The combustion of a hydrocarbon was much more perfect than that of coal; there was not the loss in smoke and clinker, and in locomotives there was none of that coating of the tubes with carbon which interfered with the conduction of the heat to the water in the boiler. One ton of petroleum was, therefore, worth two tons of coal, if not more. The great difficulty in England was the price. At present he did not think any quantity of the sort could be obtained as low as twopence a gallon, which would represent 46s. 8d. per ton, and if it had twice the calorific value, that would be equal to coal at 23s. a ton, and they could get the very best steam coal at much less than that. In Cardiff it only cost 12s. or 13s., and a very serviceable coal could be bought for considerably less. That was why liquid fuel was not used in ships, locomotives, and furnaces generally. Of course, on board ship credit must also be given for the absence of smoke, the facilities in handling, and the consequent economy in labor; but making allowance for all that, 2d. a gallon was more than the shipowner could afford to pay under present circumstances. Possibly in future, if coal reached a permanent famine price, things might be altered, and petroleum might have a chance when coal was 15s., 16s., or 20s. at the pit's mouth. Another important point was the quantity of steam required for the pulverizators. The reader of the paper said, if the pipes were properly arranged, the thing worked well, gave little trouble, and cost very little money; but in opposition to that he might bring forward statements from the technical journals with reference to the steamer which crossed the Atlantic, that for every ton of fuel used it required a ton of water from the boiler in the form of steam. This was a very costly business. It had been stated that the burners were not of a good pattern, but all this had to be taken into consideration. On rivers where there was fresh water available, this objection was diminished, and he believed in the Caspian the water was not very salt, on account of the immense flow of fresh water from the Volga. There it was patent to everybody that astatki being practically a waste substance, any loss that occurred was unimportant, but in England the matter was very different. The material had to be brought from a long distance, and cost a good deal only for transport, and at present he did not think a gallon of any kind of liquid fuel could be delivered in the Thames under 2¾d. The use of liquid fuel on the Great Eastern Railway was a special matter. Mr. Holden used the refuse from his own gas works and from other gas works, which he obtained at a nominal price, but if he had to go into the market to obtain a supply for all his locomotives it would be a very different matter. No doubt there were large districts on the other side of the Atlantic where enormous tracts of petroleum were only waiting for capital to develop them, but it was far easier to transport petroleum to England than to transport the necessary capital to the West Indies; but as to the existence of those deposits there was no manner of doubt. There were tracts both in Mexico, in the West Indies, and in other places, where immense deposits of petroleum were awaiting extraction, and if they were brought without rectification, possibly they might be delivered in the Thames at a price which would meet the requirements of engineers.

Mr. Edwin Henwood said he had some considerable experience of liquid fuel, and for four months he ran his yacht Ruby on the Thames day and night, which although not very big was as large as the original Rocket, which was the first steamer on the Clyde. The only difficulty he found was that the small amount of oil used required a pinhole adjustment, but with larger vessels, of course, a larger hole would be necessary, which would allow the oil to pass through freely. He found the evaporation obtained was considerably over 3 to 1 as compared with coal, and he had even exceeded what was claimed by Admiral Selwyn. He had been able to melt firebricks, and bring them into a liquid mass, like honey, without any difficulty. The Baku Standard, which crossed the Atlantic, was reported to have consumed over 20 tons of oil a day, as against 33 tons of coal, but unfortunately the owner did not follow the advice for which he asked, but employed a very imperfect system, or he might have done with a crude and imperfect system. For last year Mr. Suart was invited by an eminent firm of merchants to meet him (Mr. Henwood) at their offices, and was so satisfied with the success obtained with the yacht Ruby that he stated he would adopt the system, and requested plans, specifications, and estimates for fitting his steamers according to his (Mr. Henwood's) plans, which had been approved by the committee of Lloyd's Registry in 1891, and as carried out in the Ruby, whereby one ton of oil was made to do the work of three tons of Welsh coal, coupled with the exclusion of manual labor. In the Baku Standard such a result has not, it appears, been obtained. The steam was also used in a wasteful manner, and he was informed that the funnel was made red hot. Still, they found that only one man was required in the stokehold, and he had hardly anything to do but sit still and smoke his pipe. That was what his stoker told him in 1887, though the Lancashire boiler was at work day and night continuously for four weeks. On the question of supplies, he would first refer to the finding of petroleum in Somersetshire, though he did not know to what extent that had proved a success; but, apart from that, there was an immense amount of shale in this country, reaching right through from the south up to Yorkshire, from which oil could be extracted at very little cost, sufficient to supply, at under £3 a ton, all the wants of the royal and mercantile marine. Again, in Canada, there was a large tract of land adjoining the Athabasca river which might be made very productive; and, though there was a question of accessibility, he believed a moderate pipe line would bring it to a seaport. There was also another large supply near the mouth of the St. Lawrence. Again, in Trinidad there was an immense amount, but the impost of 8s. a ton made it very difficult for capitalists to deal with it, when the cost of transport was added. In Venezuela, also, there was a large amount of oil, and round the Gulf of Mexico and in the State of Colombia there was an immense amount, which was spoken of in the works of Von Humboldt in 1849, and ever since that date the oil had been running into the sea, and it might without difficulty be brought to this country, and delivered at less than 30s. a ton. Mr. Boyd said oil at anything over 3d. a gallon could not compete with coals, but he overlooked the fact that a vessel going a long voyage, which had only to carry 1,000 tons of oil, instead of 3,000 tons of coal, would have room for an additional 2,000 tons of cargo, paying, perhaps, £2 a ton for freight; besides which, there was an immense saving in labor, and in the delay and nuisance inseparable from coaling.

Mr. W. Warren, Assoc. M.I.C.E., said he thought the vibration referred to by the chairman, as arising from the combustion of the oil on its introduction into the furnace, generally arose from the injector being put at too high a point, so that there was a constant succession of small explosions. If the injector were pointed more downward the combustion took place gradually, and there was no noise. In some cases arrangements were made for increasing or decreasing the amount of air necessary for combustion, and in that way vibration could be entirely got rid of. In his own experience, in Russia, with Mr. Urquhart, the noise was entirely removed by simply spraying the oil. With regard to the excessive consumption of water on board the Baku Standard, he was surprised, after so many years' practical experience in Russia, that some better means was not adopted, and his own opinion was that the injector must have been of very defective construction, and its application still worse. In their own case, for welding and crucible furnaces, they simply took a small pipe from the blower used for providing the blast to the forges, the pressure of the air being from 11 to 13 oz., and with that they got extremely good results in the welding furnace, producing extremely clean forgings and heats. He could not but think that a small auxiliary engine and fan would have provided sufficient air for combustion, and that the Buku Standard voyage might have been a much greater success. Of course it was good in its way, because it solved a question which many people doubted. On the question of supply, there could scarcely ever be sufficient oil available, no matter how large the quantities, to enable it to displace coal, as some people thought. The entire quantity of oil produced in the United States last year was some 37,000,000 barrels, of which 60 per cent. might be taken as illuminating oil, the remainder being benzine, naphthas, and astatki, which would come to about 1,500,000 tons. The question had often been put to him whether there would not be too much oil produced, but that was easily answered, for one single railway in America, the Pennsylvania, used upward of 5,000 tons of soft coal a day, so that it would use the entire quantity of the residuum of oil suitable for fuel produced in the United States. In Russia the case was rather different. Taking the light and heavy oils of Russia, there was not more than 30 per cent. of illuminating oils obtained, leaving 70 per cent. of benzine, naphthas, and heavy oils, which might be used for fuel, but of course that meant that nothing would be available for the production of the even more valuable lubricating oils. The entire quantity, if the whole of it were available for Russia and America, would be less than 10,000,000 tons. Now the production of coal in England, in 1892, amounted to 183,000,000 tons, and in the United States it was 181,000,000 tons, or, putting it roughly, in these two countries the production was nearly 400,000,000 tons, while at the present time there was not produced more than 10,000,000 tons of oil. There need be no apprehension, therefore, on the part of any one, that the production of oil would ever exceed the demand.

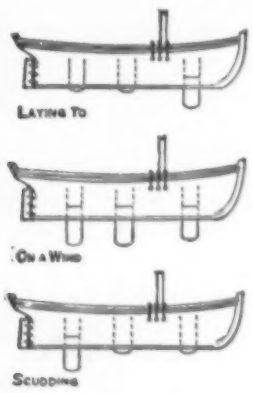
Mr. E. Charrington said the statements in the paper as to the calorific value of astatki compared with good Welsh coal were very similar to what he had found himself. Some people said that one ton would do as much work as three or four tons of coal, but in actual practice it came out about 10 per cent. better than two tons. Some experiments were carried out about a month ago on three injectors under a large copper at one of the London breweries, which was doing exactly the same work every day, and he found that they got the results he had mentioned. Of course, astatki was expensive here, and cost 25 per cent. more than the green oil, creosote oil, and tar residuals which they had been using. A ton of mixed green oil and creosote oil was equal to about two tons of coal, and, comparing the cost at 3d. per gallon, it came out equal to 16s. 6d. a ton of coal delivered in London. Of course, there was a limited supply of creosote and green oil, and at present they were using creosote only, which gave a result a little over two to one; petroleum gave about 10 per cent. better. This last year, unfortunately, had been a very bad year for the home production of tar residuals, because there was so much heat and light that the gas companies had very few residuals to dispose of, and the price had gone up. He should be only too glad if any one found out a means of using astatki so as to make it do three or four times the work of coal, as there would then be a good market for it even at the present price. On the Great

Eastern line there was 25 locomotives running, by Mr. Holden's system, and during the coal strike even the use of petroleum was found to pay, but the Great Eastern Company was under exceptional circumstances; they got their material delivered at $\frac{5}{8}$d. per gallon, and they put oil tanks into sidings, and got them filled from various gas works along the line, and then a pilot engine brought them to the works. The cost of transport was the chief trouble. There were various types of boilers, but, with locomotives, two injectors would keep up steam very well to 700 horse-power, while the same injectors on stationary locomotive boilers would maintain about 80 to 100 horse-power, whereas with tubulous boilers they would keep up to 160 to 200. The effect, therefore, varied very greatly according to the type of boiler and the draught. He knew of a case in which this system was introduced to save the expense of putting up a chimney shaft. But in England, unlike Russia, it was absolutely necessary to have interchangeability. You must be able to use coal one minute and oil the next, if necessary. Some electric light companies were using liquid fuel, but they did it more for auxiliary purposes, and in combination with coal, but not oil exclusively. Mr. Boyd had mentioned that, theoretically, the calorific value of petroleum, compared to coal, was as one and a half to one, whereas, practically, it was over two to one. That was accounted for in locomotives in this way, that the stoker simply turned off the valve in going into a station, and thus prevented an enormous waste of steam usually generated when coal is used. The amount of steam used in various injectors varied; but, on the average of a large number of stationery boilers in the works at Stratford, the steam used for two injectors, per boiler, was $2\frac{1}{2}$ per cent. of the steam generated in the boiler. Mr. Henwood had referred to the intense heat developed, and the melting of the firebrick--and that was a trouble they had to get over where it was used in the brewery referred to above. It had to be carried through a brick arch 4 feet thick, and they had some trouble to prevent the arch being melted. It was got over by having the sprays of steam from the atomizer pointing down on to the injected oil, thereby keeping the heat away from the arch. The irregularity of combustion which had been referred to arose from the injectors not working properly, and that was often found when the furnace was cold. It was only a question of regulation of the air and obtaining proper combustion. At Stratford there was a boiler in which either steam or air could be used, and, with regard to noise, there was not much difference, but it was of great importance that the steam should be superheated and perfectly dry, in order to obtain the best results. One furnace, lined with firebrick, was used in the forge for heating sometimes five blocks of iron at one time, each weighing about 6 cwt. The furnace was worked entirely by one injector, and the steam pipes supplying the injector were brought behind the firebrick lining of the furnace, and the steam was so hot you could not see it coming out of either the injector or the atomizer. There was very little noise in that case.

Mr. Stockfleth, in reply, said most of the questions raised in the discussion had been already answered by other speakers. In Russia the consumption of steam was usually estimated at from 5 to 7 per cent. The character of the flame varied with the condition of the oil. If the astatki were used very warm, a more equal and better burning flame was obtained; that was the reason of the success of the primitive injectors used in Russia. In most cases, on board ship, it was not possible to have the astatki at so high a temperature; and, consequently, a better construction of pulverizator was required. On the Black Sea and the Caspian the water was comparatively fresh, and, therefore, it was not necessary to provide special feed water. He believed astatki had been offered in London at 2d. per gallon, but a comparison could not be made by simply taking the cost price of oil and coal respectively; there were many other elements of economy, as had already been pointed out, which had all to be taken into account. Nevertheless it was not likely to be used to any great extent in this country, at present at any rate. He did not think it was sufficiently cleanly to recommend it for domestic use.

CENTERBOARD YACHTS.

IN a new English work, "Yachting and Yachts," is Mr. G. Watson's description of "the evolution of a modern racing yacht," a valuable paper in which he



traces the history of the more famous racing yachts, and gives particulars of their development, dimensions, and form. Of somewhat similar character is a chapter by Mr. Pritchett on "sliding keels and centerboards," the outcome, as he tells us, "of the shallow coasts and sand banks of New York Bay and the New Jersey coast." So long ago, however, as 1774, the system had a vogue in England, and after some trials, a brig, called the Lady Nelson, was built by the Admiralty in 1797, and fitted with three keels to be used as shown in the illustration. This vessel made a voyage to Australia. A yacht built about the same time for the commodore of the Cumberland Sailing Society, a Thames yacht club, was fitted with five such keels, but the supposed advantages do not appear to have generally impressed the yachting world.

THE OURAY AND SILVERTON RAILROAD.

THERE certainly does not exist in the whole world a railroad in which are found combined so great difficulties, that at first sight seemed insurmountable, but over which the engineers have nevertheless triumphed, as that of Ouray and Silverton, between Denver and the Rio Grande, in Colorado.

The number of obstacles that nature threw in the way of the construction of this road was so great that it is still asked to-day, not without astonishment, how science succeeded in coming out victorious from this contest in so relatively short a time. This line penetrates the heart of the Rocky Mountains, following or traversing here and there the Great Divide, the summit of the slopes directed toward the Atlantic and Pacific.

It winds through five gorges, the finest in the world, whose thousand meanderings reveal splendors that are entirely different one from the other. The sage of Veta, where the nature and configuration of the ground obliged the engineers to employ curves of very feeble radius, the shortest that one has ever dared to employ in such cases, and some of which are less than three hundred feet. In this part the road consists of a series of curves and counter curves forming true loops which almost double themselves in ascending the sides of the mountain, up to the moment when, having reached the summit, the road finally disappears in the midst of vast and dark forests of pines and spruces and buries itself in new defiles.

The engineers, in the traversing of the Great Arkansas Gorge, undertook and successfully completed the building of a structure of incredible boldness and unheard of audacity. This immense vertical-walled gorge 3,000 feet in height, and 37,000 in length, is extremely narrow, not exceeding 40 feet in width at the base and 65 feet at the summit. At the bottom of this abyss, replete with sublime horror, there runs with roaring sound a torrential river. There was no room to establish the road parallel with the river, whose bed occupied nearly the entire bottom of the gorge. Despite the difficulties that were met with,

THE OURAY AND SILVERTON RAILROAD (THE EXIT FROM THE BLACK GORGE AND THE BIG LOOP).

road afterward ascends through the defiles of four mountains in order to reach a height of more than 10,000 feet above the level of the sea, after crossing granite-walled gorges that rise vertically to a height of about three thousand feet above the rails. It runs also along fertile and picturesque valleys watered by rivers that possess historic names and traditions. Throughout its entire course, it offers the most beautiful and most varied panoramas to the gaze of the wonder-struck tourist: lofty peaks and vast plains, placid lakes and tumultuous rivers, dark gorges and verdure-clad defiles, and high mountains and terrifying precipices; in a word, all the splendors of nature seem to be found united in these places.

The Ouray and Silverton railroad renders accessible, or at least permits of a near view of, 175 mountain summits, varying from 8,500 to 10,000 feet in height, as well as the innumerable gorges and defiles that are met with in Colorado. The traversing of some of these latter necessitated some really remarkable work. For example, to the south of the Rio Grande, the railroad ascends by zigzags through the narrow pas- this obstacle was conquered like the others. From the entrance of this gorge, which at this place bears the name of Royal Cañon, as far as to its extremity, there were set into the solid walls of the rock a large number of huge iron brackets that extended their long arms into space, each of them supporting an iron yoke of colossal dimensions. All were connected by steel plate girders forming a long platform, or suspended bridge rather, upon which was laid the track of the railroad. Underneath flows the river in all its freedom at more than 150 feet below the trains.

When, running at full speed, the locomotive hauling a train begins to roll over this bridge, the traveler instinctively feels his heart coming up into his throat, amid the almost complete darkness that envelopes him, and the deafening noise of the train and of the water boiling beneath him, and which is reverberated to infinity and still further amplified by the sonorous walls of the rocks. We might enumerate by hundreds the extraordinary structures which have been necessitated by the difficulties and natural obstacles accumulated along the entire line of this very

picturesque road. At certain places the train comes out of a long tunnel to rush over a viaduct longer still and disappear anew in the rocky entrails of a mountain or to make a nearly complete circuit of it, in skirting unfathomable precipices that make a person dizzy. Then the line insensibly descends and reaches fertile valleys that it seems to leave with regret in order to again ascend the sides of other mountains of bare and arid rocks.

There is another work no less important than those that precede which deserves attention. It was executed for the traversing of another cañon called the Black Gorge, the dark granite walls of which are, on an average, no less than 1,300 feet in height. The width of the bottom of this immense ravine was not sufficient to permit of laying a track therein, and, moreover, at the period of heavy rains, in winter, it serves as a bed for a torrent, while it is entirely dry during the rest of the year. It was necessary, therefore, to manage to so place the line as to be out of reach of the water, while at the same time assuring a solid bed for it. At a height of 195 feet above the level of the highest torrential water there was excavated in one of the walls of the cañon a bench of sufficient width to allow of the safe running of a train, in following quite a steep gradient and the curve of the rocky walls of the gorge. Locomotives and cars graze the wall almost constantly, and from the interior of the cars one can perceive but a narrow strip of blue sky. The road, through very pronounced loops, descends to a deep valley, and, by very steep gradients, afterward reaches the summit of Red Mountain, after passing through the most beautiful sites of this wonderful country, Colorado.—*La Nature.*

A CORRODED BOLT.

CYLINDER oils should be free from all substances that will cause corrosion of iron, and this is true also of all oils for lubricating purposes. The bolt shown in the engraving was found in the piston of a Buckeye engine after it had been in use three months. There were three radial bolts used in the piston, and this

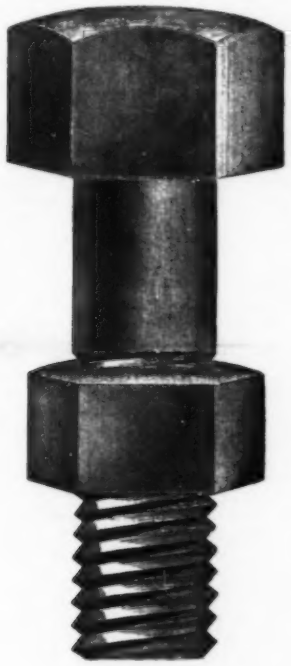


FIG. 1.

FIG. 2.

was the lowest of the three, and so placed that oil could collect about it. Opening the engine after three months, this bolt was found badly eaten away. The oil was changed and the bolt not removed, and has since run over a year without further deterioration until lately removed. Fig. 1 shows the original bolt and nut, and Fig. 2 the bolt after three months' use. None of the other bolts were at all affected, and the probabilities are that it lay in a bath of oil, the piston being arranged so oil could collect. The part not affected was screwed into the piston. The oil used was bought for a first-class cylinder oil.—*Boston Journal of Commerce.*

THE ROYAL INSTITUTION.

THE WORK OF HERTZ.

DR. OLIVER LODGE, F.R.S., recently delivered a lecture at the Royal Institution, on "The Work of Hertz." Dr. Lodge, after mentioning Fresnel, Carnot, and Clifford, as among those scientific men in whom a young and brilliant career came to an untimely end, said that they had now to add to the list the name of Hertz, who died on January 1 of this year, aged thirty-six, yet not before he had founded an epoch in experimental physics which will hand his name down to posterity. Of the seed sown by those before him in the same department of research, none had done more than Clerk Maxwell. The popular estimate of the eminence of different scientific men is sometimes more or less amusing to those working at the same subject, but this has not been the case with Hertz, who well deserves his fame, and it would be a graceful act of tribute to his memory if the Physical Society saw its way clear to collect and publish all his scattered scientific papers. His students and those with whom he worked held him in high estimation.

His lecture that evening would consist of experimental demonstrations of the outcome of Hertz's work. As a stone cast into the water sets up ripples which do not subside immediately, in an analogous manner an electrical charge or discharge of sufficient suddenness communicated, say, to a brass globe, does not settle down easily, and the oscillations of the rapidly diminishing charge excite waves in the ether. If a wire should be handy, these oscillations will run along it; otherwise they will go forth into space, varying as they go according to the law of the square of the distance. Maxwell knew that there must be such waves, and knew many of the phenomena connected with them; their length was known from a thousand miles to a foot, and even how to make them; all this was believed with varying degrees of confidence, but Hertz supplied the experimental verification. The lecturer here showed how a Leyden jar discharged through a yard of wire, and near a similar jar with closed circuit, causes an overflow of electricity in the latter, which discharges itself through a small air hole previously made in the glass, at the top of the tinfoil coatings. If the coatings of the jar be more separated a typical Hertz's oscillator is the result. The electrical oscillations soon cease, in consequence of the radiation of energy. The oscillator has to be "in tune" with the radiating source.

Hertz discovered electric synchrony; he also found the previously calculated lengths of the waves to be true in fact; he likewise observed that the secondary spark occurs more easily when it can "see" the light from the first spark, that is to say, when the light from the primary spark falls upon its knobs. Dr. Lodge illustrated this by experiment, and showed that the interposition of a piece of common transparent glass in front of the primary spark would stop the secondary sparking, for the rays which favor this effect are high up in the invisible part of the spectrum, far beyond the visible part of the violet. Glass stops these rays of high refrangibility; quartz does not stop them or but slightly stops them, so the secondary sparking continues during the interposition of a plate of quartz, as shown by the speaker. Fluorspar, he said, transmits them slightly better than does quartz. Atmospheric air in sufficient thickness, especially the air of towns, cuts off these ultra-violet rays. Helmholtz made the important discovery that under certain conditions, if a body be charged with negative electricity, and then be illuminated with these rays, it will discharge. The lecturer here projected upon the screen an image of a gold leaf electroscope, with which a small piece of zinc was connected by a wire several yards long; the piece of zinc had but a few minutes before use been well rubbed with emery paper. The leaves of the electroscope were caused to diverge by negative electricity, and upon the piece of zinc being then inserted in the path of a beam from the electric lantern with a quartz condenser, the gold leaves fell together again. This experiment was several times repeated, and it was shown that the interposition of a plate of glass stopped the effect which would otherwise have been produced by the zinc.

Dr. Lodge drew attention to a large Hertz's vibrator, analogous in principle to a Leyden jar with its coatings very wide apart, and said that it would radiate waves about 30 meters long, giving about 10,000,000 electrical vibrations in a second, and that when excited, almost all the reasonably elongated conductors in the theater would give off sparks. It would not work well that evening, however, because it had been necessary to hang it near a wall, in which when in action it produced an image of itself, which image tried to undo all that the vibrator was attempting to do. There is something analogous to this in singing flames, which will not sing so easily when placed near a wall.

Hertz found that his small sparks will start the current from a battery through a small gap in a circuit—a gap, for instance, like that produced by a bad contact in an oxidizable metal, such as iron, and Professor Fitzgerald had shown that a very delicate galvanometer would indicate when a spark passed in a Hertz's detector. The speaker here described the action of a considerable variety of detectors, and spoke of one devised by Professor Minchin, of Cooper's Hill, as being astonishingly sensitive; the instrument responds to the radiation from a star. By means of suitable vibrators and detectors, he (Dr. Lodge) at Liverpool had transmitted quite strong signals through a distance of sixty yards in the open air; he thought that the limit with that apparatus might be, perhaps, half a mile. A short spark does better than a long one to excite the vibrations. A tube of iron filings makes a suitable bad contact in an electrical circuit to be bridged over for the current by the Hertz spark, and Dr. Lodge made some use of this method in his experiments, employing also a delicate reflecting galvanometer to indicate the passage of the spark. All the brass knobs used in the experiments had to be highly polished.

Dr. Lodge showed that the radiant waves with which he was dealing would not pass through metal casing, which must be pretty complete. For instance, his detecting apparatus would not respond to the working of an ordinary electrical gas lighter while its insulating handle was wrapped round with tinfoil; the brass tube covered the rest of the instrument, but when he tore away a piece of the tin foil, and exposed a portion about as big as a shilling of the insulating handle, the detecting part of the apparatus helped to indicate the presence of the waves when the gas lighter was worked at a distance of several yards. The radiation coming from an oscillator in the library at the other end of the Royal Institution building was also indicated by the apparatus on the table. Very sensitive detecting and indicating apparatus, he said, will often be picking up such radiations coming from nobody knows where, sometimes, perhaps, from a thunderstorm a long way off.

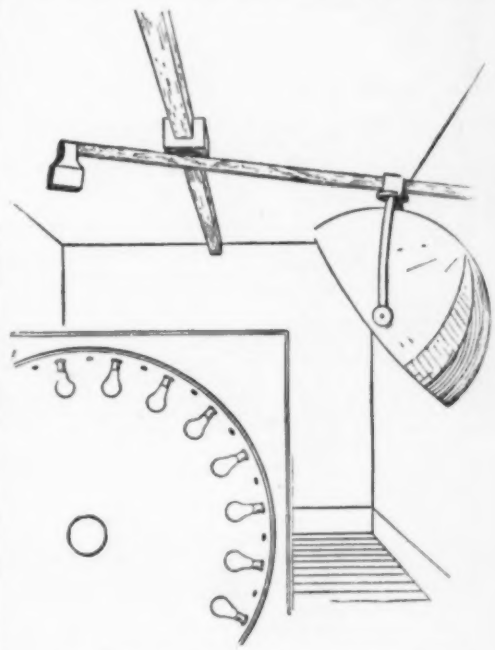
When the vibrator is placed in a copper vessel, not much of the radiation will come out through round holes of moderate size in the vessel, but much more from a long slit in the metallic covering. In his later experiments he protected all parts of the whole apparatus with copper coverings, removing the copper from those places only at which he wished the radiation to escape. Not being a physiologist, he felt at liberty to indulge in the wildest speculations on that subject, so would suggest that the eye might act in subservience to some of the principles with which he had been dealing, and vision excited by means of apparatus containing gaps of badly conducting media.

With the radiations screened off by copper covers from all directions, except those in which he wished to use them, he showed that these radiations can be refracted by a block of paraffin, also that they can be reflected from any one of its faces; the paraffin prism he used had faces of about a foot square each. He also showed that the radiations can be polarized; the polarizer and analyzer he used each consisted of parallel copper wires all in one plane, and kept in position by a wooden frame, to which their ends were attached. When the two frames were placed so that the wires were crossed, the radiations did not get through; they were at right angles to the plane of polarization. He reflected the radiations also by a copper disk; a plate of glass did not reflect them because, he said, its surfaces were too close together. He also stated that the waves he was using were 9 in. long. The copper plate formed much the best reflector.

The large attendance of many of the old friends of the Institution from among the most eminent scientific men of the day, not often now seen there together in such numbers, and the attention given to the speaker's words by all present, showed the widespread interest in this lecture, which, however, much needed wall diagrams to give precise information as to all the conditions of the experiments to those who were new to the subject.

ELECTRICITY IN THE STUDIO.

THE time has passed and gone when the advantages of employing the electric light for studio work need any demonstration. Many of our foremost workers have



adopted it, but at great cost; for they had not only to design and construct the apparatus, but to find the current wherewith to utilize it. Hence the light has been, up to the present, confined to the few. But now that electric mains are being laid through every important thoroughfare, electric lighting comes within the range of possibility for all, and we find, as a matter of course, that the dealer is making ready to supply fittings for the coming revolution in the matter of lighting.

It will be noticed, in the illustration, that the installation of Adamson's system has a certain likeness to those which have preceded it, in the employment of a concave reflector, which is capable of movement in every required direction. But with this point the similarity to other systems ends. The source of illumination, instead of being an arc light, is found in a battery of twenty large incandescent lamps—as shown in the annexed plan—a number which can easily be doubled if required. But, as a matter of fact, twenty lamps

MINERAL PRODUCTS OF THE UNITED STATES.

FOR THE YEARS 1892, 1893.

(From the report of David T. Day, Chief of Division of Mining Statistics, U. S. Geological Survey.)

PRODUCTS.		1892. QUANTITY.	1892. VALUE.	1893. QUANTITY.	1893. VALUE.
Metallic.					
Pig iron, value at Philadelphia	long tons (c)	(d) 9,157,000	$131,161,039	(d) 7,124,502	$84,810,426
Silver, coining value (e)	troy ounces	63,500,000	82,099,150	60,000,000	77,575,757
Gold, coining value (f)	"	1,596,375	33,000,000	1,739,081	35,950,000
Copper (g), value at New York City	pounds	353,275,742	37,977,142	337,416,848	32,054,601
Lead, value at New York City	short tons (h)	173,654	13,892,320 (i)	163,982	11,839,590
Zinc, value at New York City	"	87,260	8,027,920	78,832	6,306,560
Quicksilver, value at San Francisco	flasks (j)	27,993	1,245,689	30,164	1,108,527
Aluminum, value at Pittsburg	pounds	259,885	172,824	339,629	266,903
Antimony, value at San Francisco	short tons	....	56,466	250	45,000
Nickel (k), value at Philadelphia	pounds	92,252	50,739	49,399	22,197
Tin	"	162,000	32,400	8,938	1,788
Platinum, value (crude) at San Francisco	troy ounces	80	550	75	517
Total value of metallic products			$307,716,239		$249,981,866
Non-Metallic (spot values b).					
Bituminous coal (m)	long tons	113,237,845	125,195,139	114,584,796	122,751,618
Pennsylvania anthracite	"	46,850,450	82,442,000	48,185,306	85,687,078
Lime	barrels (n)	65,000,000	40,000,000	58,000,000	35,960,000
Building stone		....	48,706,625	....	33,865,573
Petroleum	barrels (p)	50,509,136	26,034,196	48,412,666	28,932,326
Natural gas		....	14,800,714	....	14,346,250
Clay (all except potters' clay)	(q)	....	9,000,000	....	9,000,000
Cement	barrels (r)	8,758,621	7,152,750	8,002,467	6,262,841
Mineral waters	gallons sold	21,876,604	4,905,970	23,544,495	4,346,734
Phosphate rock	long tons	681,571	3,296,227	941,368	4,136,070
Salt	barrels (s)	11,698,880	5,654,915	11,816,772	4,054,668
Limestone for iron flux	long tons	5,172,114	3,630,480	3,958,055	2,374,833
Zinc white	short tons	27,500	2,200,000	24,059	1,804,430
Potters' clay	long tons	420,000	1,000,000	400,000	900,000
Gypsum	short tons	246,374	671,548	253,615	696,615
Borax	pounds	13,500,000	900,000	8,699,000	652,425
Mineral paints	long tons (t)	51,704	767,766	37,714	530,284
Grindstones		....	272,244	....	....
Fibrous talc	short tons	41,925	472,485	35,861	403,436
Asphaltum	short tons	87,939	445,375	47,779	372,232
Soapstone	short tons	23,908	437,449	21,071	255,067
Precious stones		....	312,050	....	264,041
Pyrites	long tons	114,717	305,191	83,277	275,302
Corundum	short tons	1,771	181,300	1,713	142,325
Novaculite	pounds	....	146,730	....	135,173
Mica	pounds	75,000	100,000	66,971	88,929
Barytes (crude)	long tons	32,108	130,025	28,970	88,506
Bromine	pounds	379,480	64,502	348,399	104,520
Fluorspar	short tons	12,250	89,000	12,400	84,000
Feldspar	long tons	15,000	75,000	18,391	68,037
Manganese ore	long tons	13,613	129,586	7,718	66,614
Flint	long tons	20,000	80,000	29,671	63,792
Graphite	pounds	....	104,000	843,103	63,232
Sulphur	short tons	2,698	80,640	1,200	42,000
Marls	short tons	125,000	65,000	75,000	40,000
Infusorial earth	short tons	....	43,655	....	22,582
Millstones		....	23,417	....	16,645
Chromic iron ore	long tons	1,500	25,000	1,215	17,575
Cobalt oxide	pounds	7,869	15,738	8,422	10,346
Magnesite	short tons	1,004	10,040	704	7,040
Asbestos	"	104	6,416	50	2,500
Rutile	pounds	100	300	....	....
Ozocerite, refined	"	60,000	8,000	(x)	(x)
Total value of non-metallic mineral products		....	$379,971,473	....	$358,835,629
Total value of metallic products		....	307,716,239	....	249,981,866
Estimated value of mineral products unspecified (y)		....	1,000,000	....	1,000,000
Grand total		....	$688,687,712	...	$609,817,495

b. By "spot" value is meant value at the point of production.
c. "Long" tons are tons of 2,240 avoirdupois pounds; short tons are tons of 2,000 avoirdupois pounds.
d. Iron ore 1892: 16,296,696; value at mines, $33,304,896. Iron ore 1893: 11,587,629; value at mines, $19,395,973.
e. $1·2929 per troy ounce.
f. $20·6718 per troy ounce.
g. Including copper made from imported pyrites, except in 1891, for which no returns are available for matte.
h. The product from domestic ores only.
i. The lead from foreign ores, amounting to 64,373 tons, is omitted.
j. Of 76½ avoirdupois pounds net.
k. Including nickel in copper-nickel alloy, and in exported ore and matte.
m. Including brown coal and lignite, and anthracite mined elsewhere than in Pennsylvania.
n. Of 200 pounds.
p. Of 42 gallons.
q. Estimated from census returns.
r. Of 300 pounds for natural cement and 400 pounds for artificial Portland.
s. Of 280 pounds net. The reduced price in 1893 is due to omitting cost of packages.
t. Including metallic paints, ocher, umber, Venetian red, sienna, ground soapstone, ground slate, and mineral black.
x. Included in asphaltum.
y. Including building sand, glass sand, limestone used as flux in lead smelting, limestone in glass making, iron ore used as flux in lead smelting, tin ore, iridosmine, nitrate of soda, carbonate of soda, sulphate of soda, bauxite, and alum clays used by paper manufacturers.

are amply sufficient for an ordinary studio exposure of one second.

Among the advantages claimed for this system are the following: Economy, the cost of each exposure being less than one halfpenny; absolute silence of action; equality of actinism and intensity; readiness for use at a moment's notice; perfect control; non-liability to get out of order; and ease of management by any one quite inexperienced.

It will be seen, from our illustration, that the concave reflector is so mounted that it can be moved either to or from the sitter, or laterally, as may be required, and the touch of a finger is enough to cause it to move, so nicely is it counterpoised by a weight at the end of the lever by which it is supported. This facility of movement will be valued by photographers who have had any experience with the electric light for portraiture, for they well know the value of a slight motion of the illuminant during the time of exposure, however short that may be. By such a movement heavy shadows are impossible, and there is a general softness about the negative which is not readily obtainable otherwise. The disposition of the lamps in a ring as shown contributes materially to a diffusion of light which is also beneficially operative in the same direction. The movement of a simple form of switch brings the lamps into action, and this is best done gradually, so that the full radiance of the light shall not be too sudden to distress the sitter. The warm, soft glow of these combined lamps is a very good substitute for sunlight without the glare and other photographic disadvantages of the god of day. The introduction of the glow-lamp for photographic purposes is, as will be seen, quite a new departure, and there is no doubt that it offers many advantages in the way of simplicity, ease of working, and general adaptability.

In conclusion, we may note that a complete installation is on view at Messrs. Sichel's West End showrooms in Oxford Street, London.—*Photo. News.*

TONING PRINTS IN VARIOUS COLORS.

AN article on this subject was recently published in *Photographische Mittheilungen*, and also appeared in *abstracto* on page 109 of *Photographic Times*. The article has created much interest in photographic circles, and Mr. Loesher reviews it now, also in the *Mittheilungen*, explaining the different chemical processes taking place, and giving other very valuable information.

In the first place, he says, the transformation of a silver to a lead picture is not at all new. As early as 1873 Eder and Toth made lead of silver pictures, on collodion plates, the same as Mr. Wall (the author of the article referred to) now proposes to do with bromide of silver prints. Eder's formula prescribes 4 grammes of lead nitrate to 6 grammes of red prussiate to 100 c. cm. of water. The reaction which takes place is expressed by the following equation:

I.

$$\underset{\text{Ferri-cyanide potassium.}}{2K_3\,Fe_2\,Cy_{12}} + 4Ag = \underset{\text{Ferro-cyanide potassium.}}{3K_4\,Fe\,Cy_6} + \underset{\text{Ferro-cyanide of silver.}}{Ag_4\,Fe\,Cy_6}$$

II.

$$\underset{\text{Ferro-cyanide potassium.}}{3K_4\,Fe\,Cy_6} + \underset{\substack{\text{Lead nitrate.}\\ \text{Potassium nitrate.}}}{6Pb\,(NO_3)_2\;12K\,NO_3} = \underset{\text{Ferro-cyanide of lead.}}{3Pb_2\,Fe\,Cy_6} +$$

The image consists now of ferro-cyanide of lead and ferro-cyanide of silver, and can be transformed in various ways.

All the chemicals named by Wall may be successfully applied to collodion positives, but their action is entirely different upon bromide prints. The fiber of the paper imbibes naturally as much of the solutions as possible, but to wash them out again totally is impossible, and, for that reason, they should be considerably less concentrated than what a collodion plate is capable to bear.

But when the solutions are used of the strength prescribed by Wall, they act disastrously. The precipitates formed settle so firmly within the paper mass as to make it impossible to remove them by washing, and thus may the whole picture be ruined.

Wall's formulas may be divided into two groups. In the first the lead picture is toned directly, in the second it is first changed to a chromate.

Ammonium sulphydrate should be entirely excluded from the series of chemicals recommended. It attacks the picture forcibly even when much diluted, and in stronger solution it destroys it entirely. There is not the remotest reason in the process. If ammonium sulphydrate is to be used, the image should first be bleached out, and then applied.

Schlippe's salt produces a very fair reddish-brown tone, but even the most diluted solutions give color to the ground of the picture.

Subchloride of cobalt gives a good light-green tone, but the color of the picture contrasts but slightly with the should-be white ground. Pure whites may be had when washing the lead picture to almost an interminable extent.

Nickel subchloride acts quite well upon collodion films; upon bromide paper I could not get the slightest effect.

Quite erroneous are the formulas for making yellow pictures. Potassium bichromate and potassium chromate in solution 1:9 do well with collodion plates, but the whole paper of a bromide print would be stained intensely yellow, impossible to remove by washing. Diluting the solution in the proportion of 1 in 500 would be still active enough to give the white a permanent yellow tone.

With iodide of mercury the tones are yellow, the whites remain clear, but the tones are mat and not at all handsome.

Chromates of potassium spread uniformly over the whole surface of the paper, and are imbibed by it. To remove them by washing is impossible, a fact which makes *Wall's second group of toning* impracticable.

Eder and Toth's examples of the great variability of chromate pictures have probably misled Wall. A variety of transformations are, of course, possible, wherever a chromate is present, but as the chromates have permeated the entire paper, clear whites are not attainable.

Wall's toning with ferric chloride, potassium permanganate, cupric chloride, potassium iodide, and uranium nitrate are, therefore, entirely out of all consideration.

Preliminary preparing of the paper with chromates is of no avail. The more the paper is maltreated, the more it is subjected to repeated reactions, baths, washings, etc., the more inferior will be the results.

A fairly good brown picture may be had by treating the lead picture directly with potassium permanganate. The solution should, however, not be stronger than 1 in 500, but even then the ground will show a slight color.

Cupric chloride produces a brown of similar color, but sulphate does still better. Potassium iodide tones are not permanent. Uranium nitrate and chloride of ammonia changed the lead picture to a handsome reddish-brown. Dr. E. Vogel has used this method with much success.

Wall's reactions are herewith exhausted. Useful have proved the following only:

REDDISH-BROWN.

	Parts.
Uranium nitrate	1
Ammonium chloride	1
Water	10

BROWN (BLUISH).

Copper sulphate	1
Water	10

GREEN.

Cobalt subchloride	1
Water	10

BLUE.

Ferric chloride	1
Water	50

YELLOWISH-BROWN.

Potassium permanganate	1
Water	500

It is impossible to lay down strict rules for this method of toning. Thoroughly developed negatives of good density give better results than the feeble; the latter produce monotonous tones, with lights scarcely distinguishable. Wall prescribes to over-expose, and to develop but weakly. I found the results of his method, writes Loesher, rather inferior to my own. The fixed and washed bromide print is to be first immersed into the lead bath, where it remains till its color turns yellow. Washing changes the deposit to white, after which one of the above mentioned toning processes may be applied. Whether any or either of these tones are durable, we cannot yet say.—*Photographic Times.*

PASSAGE OF HYDROGEN THROUGH PALLADIUM.

AT a recent meeting of the Physical Society, Professor W. Ramsay, F.R.S., read a paper on "The Passage of Hydrogen Through a Palladium Septum, and the Pressure which it Produces." After referring to the analogy between osmotic pressure of solutions and

the behavior of hydrogen and palladium, the author described the apparatus he had used in his experiments, and showed it in operation. A vertical platinum tube provided with a palladium cap is inclosed within a glass vessel through which hydrogen and other gases may be passed, and outside the glass vessel is a vapor jacket by means of which a constant temperature can be maintained. The lower end of the platinum tube communicates through a graduated capillary tube with an adjustable manometer, which enables the volume of the inclosed gas to be kept constant.

Great precautions were taken for insuring purity and dryness of the gases used. After filling the palladium and platinum tube with dry nitrogen at atmospheric pressure and the desired temperature, hydrogen was passed through the glass vessel. Some of the hydrogen permeated the palladium walls, thus increasing the pressure inside. After some time (usually an hour or so) the pressure attained a steady value, and the total increase was then observed. Experiments were made with air, nitrogen, nitric oxide, nitrous oxide, carbon dioxide, carbon monoxide, and cyanogen in the palladium tube, and in some cases the hydrogen was diluted with nitrogen. In all cases the maximum pressure of the hydrogen within the tube was less than that of the hydrogen outside the tube.

After the palladium had been used once or twice, it became coated with mercury (vaporized from the manometer), and lost its permeable properties. It was found necessary to heat the tube to remove the mercury, and then dissolve off the oxide of palladium thus produced after each experiment. The permeable nature of palladium was found to depend greatly on the temperature, for at 232° Cent. the passage of hydrogen was so slow that the internal pressure was still rising after ten days; at 330° the passage was very rapid. An attempt to use the apparatus for giving a continuous indication of the amount of hydrogen in coal gas failed, because the palladium did not retain its activity sufficiently long. Other experiments showed that nickel is impervious to carbon monoxide.

In the latter portion of the paper the author discusses the various "so-called" explanations which have been given of the phenomena, but finds none satisfactory. Experiments in the absorption of gases by platinum and other metals are in progress, with a view to the further elucidation of the subject.

Mr. Mond thought the fact that rise of temperature accelerates diffusion tended to confirm Graham's view that the gases pass through openings in the solid, for increase of temperature would widen any pores which might exist in the metal.

The president inquired whether the author's argument against the possibility of palladium hydride condensing in the pores of the metal, because of its being unstable at the temperatures employed, would be affected by the fact of water being capable of existing in contact with glass at temperatures much above boiling point.

In reply, Professor Ramsay said the president's suggestion might be true, but if so another condition must be fulfilled, viz., that the hydrogen molecules must be split up into the atomic or nascent state.

THE LIQUEFACTION AND SOLIDIFICATION OF AIR AND GASES.

By HENRY WURTZ, Ph.D.

MATTER is generally classed under three distinct forms—solids, liquids and gases. This is popularly accepted and regarded as a sound division and definition.

But it is now well recognized by science that there are various intermediate forms between the perfectly solid and perfectly liquid states of matter. Absolute solidity involves rigidity, pressure leading only to fracture. From this some have held that all true solids are crystalline in structure. But there are true solids whose form can be changed only by fracture, yet totally devoid of crystallinity. Gelatine (solid) is one good example; shellac another. But among the solid bodies most handled by mankind, such instances as these are rather exceptional. An increase of pressure over that of the atmosphere will in most cases change the form of a substance seemingly solid, without fracture, proving more or less flow of its internal molecules. Some substances, like asphalts, pitch, paraffine waxes, etc., change their forms by their own weight, and, like liquids, return to their level (though slowly), unless kept very cold; and there are few substances which do not, on rise of temperature, develop these semi-liquid, plastic or malleable and viscous or ductile consistencies. Some require for this more, and some less, heat. There are also gelatinous substances, like India rubber and others, which resemble liquids in returning at once to their level (so to speak). Such possess plasticity and elasticity combined. These facts have been somewhat dwelt upon to show that our accepted classification into solids and liquids is not a natural one, and applies with strictness only to extreme cases. Mere changes of temperature subvert it and throw it into confusion.

Between the liquid and gaseous forms of matter, however, there are as yet no distinct indications of any intermediate conditions, unless we consider the *vapor* state as being such. In the case of saturated steam, for example, it is familiarly known that the vapor, when first formed, at 212°, contains some 966° per pound of "latent heat" of vaporization. But it is not so well known—indeed has apparently escaped attention altogether, so far as the writer knows—that, according to the accepted formula of Regnault, on rise of temperature this latent heat gradually diminishes and must become free or sensible heat of temperature. At about 1,600° Fah. it should altogether disappear, and steam should then become perfect gaseous water. Through ignorance of this, all calculations of flame temperatures (except those of Bunsen) have been vitiated. It is probable that this applies to all volatile liquids and to liquefied gases, being possibly connected in gases with the rapid departures from the law of Boyle above 10 atmospheres of pressure.

The first gas converted into a liquid was *chlorine*, in 1805—the history of this subject being, therefore, now about ninety years old. This liquid was discovered by an English chemist named Northmore, by applying a pressure of some 20 pounds per square inch to chlorine gas cooled by ice. It remains liquid, under the ordinary pressure of the air, at 29° below zero Fah. It is very difficult, however, to solidify, not freezing at 130° below zero. It is yellow and one-third heavier than water. It is now manufactured and sold, inclosed in strong reservoirs, for bleaching and disinfecting uses. It has other uses also, some of recent discovery and of high importance, which cannot be explained here.

Eighteen years passed before the great chemist Faraday, in 1823, took up the subject of the liquefaction of gases. His inventive genius at once struck out a new path—followed in this fertile field, in certain ways explained below, up to the present day. This was to generate the gas to be liquefied, by heating a compound or mixture that evolves it in one limb of a glass siphon, both ends of which were sealed. The other limb of the siphon was immersed in a freezing mixture when found necessary. The gas was thus liquefied in the cold limb by the pressure proceeding from its own expansion. He thus obtained new liquid bodies from gaseous *carbonic acid*, *sulphurous acid*, *nitrogen trioxide*, *laughing gas*, *cyanogen*, *ammonia*, *olefiant gas*; and from *hydrochloric*, *hydriodic* and *hydrosulphuric acid gases*. So that, up to 1823, over seventy years ago, *eleven* gases (including chlorine) had been liquefied. Thenceforth all chemists believed that we would ultimately attain to the means of liquefying all gases. But a "weary time" passed before these anticipations were realized. It was more than half a century (55 years) before hydrogen, the last of them, yielded, in 1878. The heaviest pressures that could be contrived by mechanical devices were applied to all, in conjunction with the greatest degrees of cold then attainable, with few results further than those already obtained by Faraday. Modes were found, however, which are now employed for obtaining some of Faraday's products on a commercial scale.

There were especially certain individual gases, as *oxygen*, *nitrogen*, *hydrogen*, *nitric oxide*, *carbonic oxide*, *marsh gas* (natural gas, fire damp) and *acetylene*, which presented a peculiar behavior. After being compressed very heavily they underwent little or no further condensation by further compression, but nevertheless did not become liquid. These were for a time given up by most chemists, and designated as "incondensable gases." It was not until 1860 that the English chemist Andrews made a certain discovery which created much sensation in the scientific world. Cagniard de la Tour had made similar experiments in 1822, but had not recognized their real significance. Andrews called his discovery that of a "continuity" between the liquid and gaseous states of matter. The application of this expression is not clear. It is a familiar fact that if a vapor of a volatile liquid, such as ordinary steam, be submitted to pressure, a certain amount of it will be compressed into the liquid form. Andrews found, however, that when any such vapor reached certain temperatures differing with the vapor, no pressure whatever would effect the smallest liquid condensation. Such temperature he called the "critical temperature" of the gas or vapor, which is a good term. That for steam is about 685° Fah.; that for carbonic acid gas, 87½° Fah. In other words, at and above their critical temperatures, liquids boil inevitably, under all pressures however high. They boil and spring into vapor, even when the whole space is filled with the liquid, and in that case we get vapors as dense and heavy as the liquids themselves. It appears therefore that liquids possess real boiling points independent of pressure. The significance of this principle, in many ways, is enormous. As an example, its application to volcanic theories.

This principle having been recognized, it followed, as a matter of course, that the "incondensable" gases had never yet been cooled down below their critical temperatures, and could not therefore have been liquefied by any pressure, however great. This gave a new impulse to the workers in this field of experiment, and they devised improvements in the modes of obtaining low temperatures, mostly founded on what may be called *cumulative* freezing methods, which had already been much used with solid freezing mixtures and which were now applied to the production of more intense cold by the evaporation of one liquefied gas, which had been previously chilled intensely by the evaporation of another liquefied gas, and so on still further. Moreover, another device was introduced in combination, the use of air pump exhaustion for increasing the rapidity of these successive evaporations, and thus further intensifying the cold greatly. As an example, one liquid used in this way has been liquefied olefiant gas, or ethylene, which, though it can be liquefied under heavy pressure, even at the ice temperature, has the wonderfully low boiling point of 157° below zero Fah., and in a vacuum 213° below. When this liquid ethylene has been chilled by the evaporation around it in a vacuum of liquid sulphurous acid, and then this chilled ethylene itself boiled in a vacuum around a tube or vessel containing oxygen gas or air, the latter becomes liquefied.

By the above method, substantially, the Russian chemists Wroblevsky and Olszewski liquefied oxygen, nitrogen, marsh gas, etc. For liquid oxygen they found the boiling point 294° below the Fahrenheit zero, and for its specific gravity at this temperature a maximum of 1·137. A curious circumstance is that these chemists obtained their oxygen as a colorless liquid, whereas both Pictet and Dewar have uniformly reported liquefied oxygen as exhibiting a light blue color. The boiling point of liquefied nitrogen was as low as 318° below zero; and its specific gravity at the boiling point 0·83.

Dewar had also used liquefied ethylene largely in liquefying oxygen, nitrogen and air, in recent public lectures in London and elsewhere. He has even gone a step further and by surrounding a tube containing dry air with boiling liquefied oxygen, first obtained by means of the boiling ethylene, and applying the air pump, he has not only liquefied the air, but frozen it solid. Such frozen air has also been produced by Pictet.

By similar processes—and with apparatus which would require cuts to make clear—the French chemist Cailletet, and the Swiss chemist Pictet, of Geneva, succeeded first, almost simultaneously, in liquefying the lightest of the gases, hydrogen, and the last named went further still, obtaining hydrogen in a solid form, though not so that it could be handled and closely examined. Cailletet's results were obtained on December 30, 1877, and Pictet's on January 10, 1878, the interval between being but eleven days. Indeed Pictet's results were the first published to the world. Cailletet's methods had the great advantage over those of Pictet, that his liquid hydrogen was condensed in a glass tube, so that it could be seen, while that of Pictet was obtained only in an opaque metallic cylinder. Many chemists had expected that when hydrogen should be liquefied, it would turn out to be a metallic body, say like quicksilver, at least in aspect. But Cailletet's liquid did not justify this expectation, being transparent and colorless. Pictet, who obtained jets of his liquid hydrogen from his metal cylinders, says that when brightly illuminated by an electric light, these jets presented an opaque steel blue color; implying that he regarded his product as metallic. This may have been an illusion, though, considering the source of the statement, this is hard to credit. Pictet's pressure for hydrogen liquefaction was 360 atmospheres, or 5,300 pounds per square inch, and his temperature 236° below the Fahrenheit zero. He states that when the jets referred to, or the spray from them, fell on a solid surface, a rattling sound was heard, as from seed or small shot. This of course argues that the hydrogen was frozen solid by the cold from its own evaporation. With regard to Cailletet's work, it may be added that he liquefied also with his apparatus and methods, oxygen, nitrogen, marsh gas, carbonic oxide, and acetylene.

The *cui bono?* the question as to what utilities to mankind are to follow from these conquests over the "incondensable" gases, made within the last seventeen years, it remains for the future to answer. Scientific discoveries have often been compared to babies, which have to be reared up to maturity with expenditure of care, time, labor and money, and whose future utility to mankind may be small, or very great, as may have been decreed by the Creator of all. This parallel, however, is in one respect totally fallacious. The baby has but a transient race to run, while the scientific conquest over nature, once made, is for all time. The same cry of *cui bono?* was raised regarding the earlier discoveries of Faraday and others, in liquefying the more easily condensable gases. Let us see what has been the outcome already, within seventy years, of these earlier discoveries—by considering some of them individually, introducing such details as may interest both the practical man and the general reader.

Carbonic Acid Gas (Carbon Dioxide).—This requires for liquefaction at 60° F. 565 pounds pressure per square inch, or 38½ atmospheres. It forms a transparent, colorless, highly mobile liquid, that floats on water. Its specific gravity varies much, as obtained by different skillful chemists, the following figures having been found, all at 32°: 0·83, 0·909, 0·93 and 0·9471. This is analogous to the case of carbon itself, as is familiarly known, in its different polymeric forms of charcoal, gas carbon, graphite, diamond, etc., so that there must be similar polymeric forms of liquid carbon dioxide. It may be added that the figures obtained for the specific gravity of carbon dioxide, even in *gaseous* form, present two distinct sets, as found also in the case of gaseous oxygen and ozone. This, with similar facts relating to vapors of sulphur, and some other bodies, implies the prevalence of such polymerisms in gases, as well as in liquids and solids.

Liquid carbonic acid is the most expansible body known (with certainty); being more expansible than air. Thus, while 100 volumes of air (or other gas) at 32° become at 42° 102 volumes, 100 volumes of liquid carbon dioxide at 32° become at 42° 103¼ volumes. Some other liquefied gases expand more than air. Its boiling point, in the open atmosphere, is 109° below zero. In Europe, where it has now for a number of years been manufactured and sold, and exported throughout the world, condensed in strong iron cylinders, it has been long since proposed, and probably used, for ice manufacture; being much the cheapest of the liquefied gases. For refrigeration of vessels, cars, warehouses, etc., it is the least objectionable among them, and has been preferred especially for steamers. In Krupp's works, at Essen, it has been employed for bringing enormous pressures to bear on melted steel in moulds, to prevent the formation of "blow holes." The most extensive use is of course for making mineral waters, and for aerating wines and other beverages. Experiments are said to be in progress now for perfecting and extending its use as a motor agent, for which it has hitherto been confined mainly to torpedo boats. A highly important use, which should be developed and extended as fast as possible, is for extinguishing fires in inclosed spaces, as on shipboard, in warehouses, etc. It has been used for raising sunken vessels with success; and a German ironclad is stated to have been thus raised.

When this liquid is allowed to spurt out into the air in a small jet, so much cold results that a portion is frozen into a mass resembling snow or magnesia. This, mixed with ether to a sort of slush, forms a freezing mixture of a temperature of 110° below zero. It is not an electrolyte, and is a poor electric conductor. Its solvent powers on other bodies are feeble.

Sulphurous Acid Gas (Sulphur Dioxide).—The gas formed when sulphur burns in the air. It is extensively employed in liquefied form, mainly for ice making and refrigeration generally, by Pictet's methods. It is also very cheap. It is an invaluable disinfectant, insecticidal and germicidal agent, and is used also largely for bleaching purposes. Its extensive introduction into commerce in liquid form, in portable reservoirs, is an assured thing of the near future. Liquid sulphurous acid boils at a temperature so (comparatively) high, 17½° F., that its liquefaction may be shown by sudden compression in a glass syringe. By its evaporation in a current of air, a cold of 50° below zero is obtainable—low enough to freeze mercury. In a vacuum it freezes by its own evaporation to a snow-like mass. The specific gravity of the liquid at 32° is about 1·43. Its lower tension at ordinary temperatures makes it easily manageable. It dissolves iodine, sulphur, phosphorus, and resinous bodies. Pictet obtained with it, by rapid exhaustion of the vapor from the liquid, a cold of 85° below zero, with which he succeeded in liquefying carbon dioxide and laughing gas, at the comparatively low pressures of 50 to 108 pounds per square inch; using the latter in his operations for the liquefaction of hydrogen.

Ammonia Gas.—This, in liquefied form, is now a quite familiar agent. The large establishments for

artificial ice manufacture, and many of the "cold warehouses" and refrigerated cars employ it. The movements now being made to distribute refrigerated air throughout cities are also destined to develop immensely the preparation and use of liquefied gases. The methods of the French inventor Carré, with liquefied ammonia, are, so far, the most important of these developments. They depend on producing cold by the evaporation of liquefied ammonia, the gaseous ammonia thus formed being absorbed by cold water, which at 32° takes up 87½ per cent. of its weight of ammonia. Liquefied ammonia is then reproduced by warming this solution, and passing the cooled ammonia gas evolved into a confined space, where it liquefies again by its own pressure; after the original device of Faraday. Thus, not only have the new bodies, the liquefied gases discovered by Faraday, over which the *cui bonot* lament was made, come into extensive and increasing practical use, but even his novel modes of preparation and handling of them have been adopted and adapted by inventors and manufacturers. We therefore owe to the genius of this chemist the most essential elements of the valuable modern art of making artificial ice from purified and sterilized water. It is stated that by Carré's plans the burning of one ton of coal has made ten tons of ice. Doubtless the manifest superiority of this chemically made ice over nature's purest product will soon lead, as it should, to the entire displacement of natural ice in our cities at least.

Liquefied ammonia is a very remarkable body, and has properties and utilities yet undeveloped. One of the most surprising was discovered by an American chemist, Charles A. Seeley (now deceased). He found that this liquid ammonia has the power to dissolve certain solid metals, as the alkali metals, sodium, potassium and lithium, forming transparent blue solutions—not compounds, but true solutions. This latter he proved by showing that on mere evaporation of the ammonia, the metals were left with unchanged properties.

Liquefied ammonia has the specific gravity at 32° of 0·6364, and its tension at 60° is over 1,000 pounds per square inch. So that, as a commodity for transportation, the risk is certainly considerable. There are other valuable uses that will arise out of this high tension, together with its rapid absorption by cold water.

Chlorine Gas.—This was the first gas liquefied, as mentioned before. It is easily and very cheaply prepared by the Weldon Pechiney process, though in admixture with other gases. But on compression of the chlorine to liquid form, it should be separated from these foreign gases.

Laughing Gas (called by chemists nitrous oxide, or, more strictly, dinitrogen monoxide).—This is another gas that has been introduced into commerce in cylinders, in liquefied form, notwithstanding its very low boiling point, which is away down to 126° below zero—implying an exceedingly high pressure at ordinary temperatures. It would appear safest to transport this agent in aluminum-bronze cylinders in refrigerated cars or vessels, and transfer it, for sale and distribution, to portable reservoirs in highly compressed gaseous form only. It is now just half a century since, in 1844, the first tooth was extracted from Dr. Horace Wells, of Hartford, while under the influence of laughing gas, by Dr. Colton. This was doubtless the first public practical demonstration of the grand discovery of *anæsthesia*, though it is believed by many that the Boston chemist, Dr. Charles T. Jackson, previously knew of ether anæsthesia, and had employed it privately.

Besides its universal dental uses, laughing gas is now held by numerous orthodox physicians to be a general remedial agent of high value, especially in nervous disorders, insomnia, and even in the terrible forms of mania called melancholia. This liquid is one of those which, like liquid carbonic acid, expand with rise of temperature more than gases. When poured into water the latter suddenly freezes solid, and there is an energetic explosion, from rapid gasefaction of the nitrous oxide. An interesting lecture experiment is to pour it over some mercury in a glass, and then throw in a piece of lighted charcoal. The mercury instantly freezes solid, and remains so, while the charcoal undergoes the most dazzling combustion in the nitrous oxide gas.

Pictet has not long since claimed that by the use of the intense cold of liquefied gases a number of chemical and medicinal agents can be obtained *absolutely pure*, impurities being either frozen out or remaining behind unfrozen on the solidification of the general mass. He mentions alcohol, ether, chloroform, etc. Coal tar benzole has long been purified by congelation. Pictet has been engaged during the last year in investigating the power of these excessively low temperatures in disinfection and the destruction of disease germs. Last September he reported almost incredible results, inasmuch as they included the fact that pathogenic bacteria actually retain their venom undiminished at a temperature more than 350° below the Fahrenheit zero! He produced this cold by means of atmospheric air frozen solid—air-ice we might call it—such as Dewar also has recently produced. Dewar has lately confirmed the above extraordinary fact at least down to 206° below zero, and has also found that the vitality or germinating power of some seeds was not destroyed by this latter temperature.

Dewar has been in later years one of the most industrious and successful experimenters in the field of gaseous liquefaction; especially with reference to the liquefaction (and solidification) of air and its component gases. He has improved the modes of preparation, so as to obtain these liquids, as reported, "by the pint." He takes highly compressed oxygen, and first chills it by the evaporation of liquid laughing gas, and then submits it to the cold produced by the boiling of liquefied ethylene in a vacuum. Nevertheless Dewar obtains in liquid form, as he states, but one-tenth of the oxygen he operates on. This illustrates well the present embryonic stage of the subject. Dewar has further discovered a most important mode of handling liquefied air and oxygen in open vessels, without the constant ebullition that has heretofore made it impossible to observe closely the properties of these bodies. This mode consists in jacketing the glass vessels containing the liquids, which are hung up in mid air, to avoid heat from contact with glass jackets, that is making them with double walls, and then exhausting *absolutely all* the air, by improved mercurial pumps, from the interspace. He states that even a thousand millionth part of the air left in this interspace will manifest its presence by convection of heat to the liquefied gas.

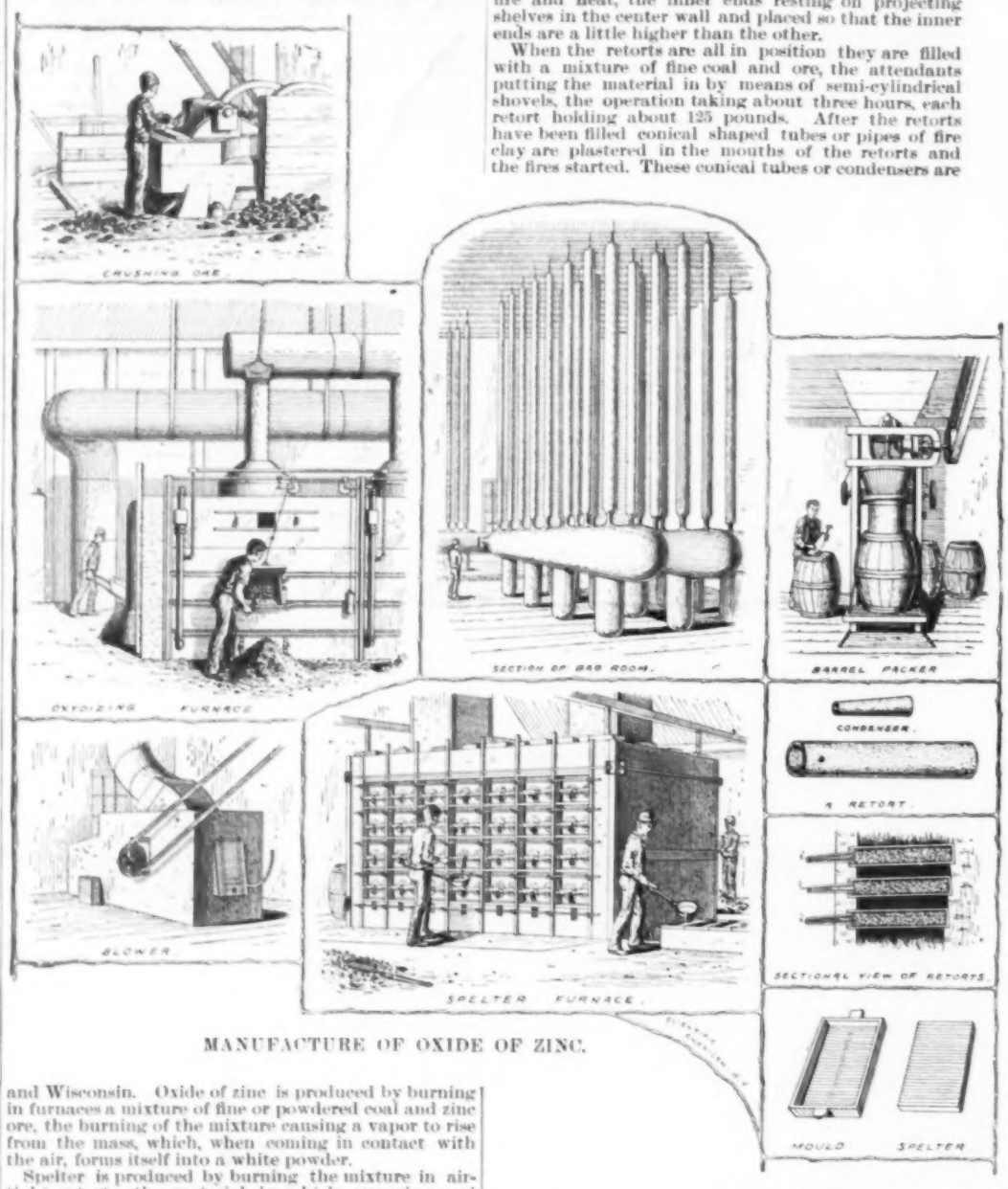
Pure liquid oxygen he finds to have a pale blue color and to be taken up by a magnet, having one thousandth part of the magnetic attractability of soft iron. Faraday long ago discovered the magnetic quality of *gaseous* oxygen. Dewar finds, contrary to views hitherto held, that intense cold intensifies magnetism. A bar magnet increased in power in liquid air 50 per cent. His most remarkable results, among many, relate to the effects of these low temperatures on metals.

First: Their tensile strength is increased very greatly. A piece of iron which stood 34 tons stress increased to 64 tons in liquefied air; 88 per cent. increase.

Second: The electric resistance decreases so much that Dewar concludes that at what is called the "absolute zero," "all metals should become perfect conductors"!

MANUFACTURE OF OXIDE OF ZINC.

THE zinc ores from which oxide of zinc and spelter are manufactured come principally from the States of New Jersey, Pennsylvania, Virginia, Illinois, Missouri, and Wisconsin. Oxide of zinc is produced by burning in furnaces a mixture of fine or powdered coal and zinc ore, the burning of the mixture causing a vapor to rise from the mass, which, when coming in contact with the air, forms itself into a white powder.



MANUFACTURE OF OXIDE OF ZINC.

Spelter is produced by burning the mixture in air-tight retorts, the material in which vaporizes and forms itself into liquid zinc. The oxidizing furnaces are made of iron and brick, the inside of which is lined with fire brick. The burning spaces are about 6 feet in length, 4 feet in height, and about 4 feet in width. A charge—of which there are six daily—consists of about 400 lb. of fine coal and about 550 lb. of zinc ore crushed, which is moistened with water. When the furnace is ready to receive the charge, the mixture is put into the oven. After burning about one-half hour, an upper door of the furnace is thrown open to let the gas escape and prevent explosion. As the heat from the burning mass increases, a vapor from the heated ore arises, which is carried off through an 18 inch pipe or chimney, by means of a blast underneath the bottom of the furnace. This blast admits the oxygen, which, coming in contact with the vapor, causes it to form itself into a white powder. Running horizontally and attached to the pipe at the top of the furnace is a 4 foot pipe, which connects itself by an underground passage to a blower, which carries or forces the powder up into what is called the bag room. The pipes from the blowers run across the center of the room, connected to which every few feet apart, on each side, are a number of muslin bags ranging in diameter from 1 to 4 feet. The small bags are suspended to the rafters 50 feet above and are connected at the bottom to the large 4 foot bags, which run horizontally each way across the room, underneath the bottom of which are a number of 2 foot teats. The oxide of zinc is blown from the pipes into these bags. After a quantity is collected, the blower is stopped and the bags collapse and are shaken by the attendant, causing the material to settle down into the teats, where they are emptied in common bags and then screened and bolted. After being bolted the material passes to the barrel packer. The material passes down through a hopper and into a metal cylinder about the length and the diameter of the top of the barrel. Running down through the center of this cylidner is an upright shaft, connected to the end of which is a wheel similar in shape to that of a propeller. When the machine is in motion the upright shaft and wheel revolve, the material passes out through the blades, at the same time pressing and packing it against the bottom of the barrel, which has been raised on the movable platform of the machine. As the quantity increases through the blades, the barrel gradually lowers until filled and another takes its place. The spelter furnaces are also made of iron and brick. They are square in shape and worked from both sides, the furnaces being divided off by a fire brick wall about one foot in thickness running across the center. The distillation is carried on in cylindrical fire clay retorts. These retorts are about 5 feet in length and about 1 foot in diameter and 1½ inches in thickness. There are 56 of these retorts on each side, placed in rows, so that they can be encircled by the fire and heat, the inner ends resting on projecting shelves in the center wall and placed so that the inner ends are a little higher than the other.

When the retorts are all in position they are filled with a mixture of fine coal and ore, the attendants putting the material in by means of semi-cylindrical shovels, the operation taking about three hours, each retort holding about 125 pounds. After the retorts have been filled conical shaped tubes or pipes of fire clay are plastered in the mouths of the retorts and the fires started. These conical tubes or condensers are about 18 inches in length, about 5 inches in diameter at the base and taper down to about 3 inches at the mouth. As the temperature increases, small jets of flame of different colors issue from the mouth of the condensers; when it becomes a dazzling white it shows that the material is vaporizing and forming into liquid zinc, which begins running into the condensers. The condensers are drawn every 24 hours, the attendants emptying them by means of long iron rods ladle-shaped on the ends. These are drawn back and forth, drawing out the liquid zinc, which runs into iron receptacles held by the attendants. They are then taken away and moulded into 40 pound cakes of spelter. The retorts last from 2 to 6 weeks, the upper ones lasting the longest, on account of their not being close to the fire. The production of spelter in net tons amounts to about 40,000 tons yearly. The sketches were taken from the manufactory of the Passaic Zinc Company, Jersey City, N. J.

GASES IN KILAUEA.*

By WILLIAM LIBBEY, Jr.

IN 1865 Mr. W. T. Brigham called attention to the existence of certain bluish-green flames which broke from the crust of Halemauman during a disturbance of its slag-like surface.

In 1887 Mr. Emerson, of the Geological Survey of the

*Abstract of a paper published in the *American Journal of Science*, vol. xlvii., May, 1894.

Islands, and several others identified these same flames. They are referred to in Prof. Dana's book upon "The Characteristics of Volcanoes" (p. 119) as being pale in color and of a slightly greenish color rather than bluish. This corresponds with my observations. In order to test this matter I took with me upon my recent visit to the volcano (Sept. 14 to 25, 1893) a pocket spectroscope. I did not imagine that I should have such a splendid opportunity, or I should have taken a better instrument; however, the little spectroscope did good service, and the observations may possibly lead to something better later on.

I spent the greater part of three evenings down on the edge of the boiling caldron in Halemaumau, and the observations I made were repeated many times, so that I have every confidence in them. As to the conditions, I may say that they were exceptionally favorable. The surface of the molten lava was so high during the whole of our visit that it could be reached with an ordinary walking stick. The volcano seemed to be in a very active state, as several overflows occurred, and the ebullition from what appeared to be three centers of weakness or disturbance was very remarkable. The lava was thrown into the air a distance of 40 to 50 feet, and as we could approach these fountains quite closely in two instances, we could form very good estimates of their size and the amount of lava involved in such an outbreak. Their surface for a considerable area near one of these centers (for they seemed very constant in position) would sway up and down, at first gently and then more violently, particularly in the neighborhood of the intersection of the fissures, which were constantly forming in the crust of slag, then there would be two or three small explosions accompanied by a bumping sound, as though gas had escaped from the mouth of an uncorked bottle; after this there would be a great rush of lava into the air, to be repeated several times, when the surface would become quiet once more.

At the edge of this caldron, 1,000 feet in diameter, I placed myself after dark, and for a couple of hours in each instance had opportunities nearly every five minutes to observe the flames which almost invariably accompanied these explosions. At times they would make their appearance along the fissures in the crust, when they would be very short lived; and I failed to get much information from them, aside from the fact that they seemed to be the exact counterpart of the hydrogen flame from a Bunsen burner.

It was the study of the flames which accompanied the larger outbreaks which appeared to promise most return. Getting as near as possible to one of the giant fountains (probably 50 yards distant) I watched for the premonitory symptoms of an outbreak and got all ready for it, and seldom failed to catch indications of the presence of gases.

For a good part of the time there was a continuous spectrum while the spectroscope was directed across the lava. The first thing that impressed me was the sudden appearance and disappearance of broad *bands* of white light, showing conclusively the presence of gas burning under high pressure. The location of these bands became the next problem, and then I longed for a better instrument with a micrometer eyepiece. The first which appeared with constancy was a band in the green, indicating the presence of carbonic oxide in all probability. Then I found on other occasions bands of lighter intensity in the red and blue, and the red and purple portions of the spectrum, thus apparently marking the presence of the hydrocarbons. There were also occasionally noticed upon a full spectrum a large series of dark lines in the yellow and orange, sometimes completely blotting these colors out of the spectrum altogether. These need more careful study before assigning them definitely to any substance or substances.

It is hoped that the above may serve to indicate a point upon which valuable work can be done, and that some one will take advantage of it and follow the subject up.

CRYSTALS IN BOOKS.

By A. F. TAIT.

IN a certain "kind play-book" known as "Love's Labor Lost," Sir Nathaniel speaks of the "dainties that are bred in a book," but the dainty bred in books known as the dendritic crystal, which is the subject of this paper, never came within Sir Nathaniel's observation.

It is a curious fact that the dendritic crystal, one of the most interesting and most lovely of crystalline forms, is almost unknown, and has only lately come

DENDRITIC CRYSTALS IN BOOKS.
1 and 3, natural sizes; 2, magnified.

within the ken of workers with the microscope. Still more curious is the fact that most of us possess specimens, and some of us dozens of really fine examples, and we never knew until now that we possessed them. Only the initiated know the home of the dendritic crystal, for, as Mark Twain said of international law, the subject is "not yet hackneyed." Being, then, so new to observers, the crystal in question is not even named in the usual text books. I must, therefore, beg the indulgence of my readers for the fragmentary and imperfect character of this paper, based solely on personal observation. The dendritic crystal (from the Greek, *dendron*, a tree) may be found where Nature is holding a perpetual exhibition of specimens at once brilliant, beautiful, and practically indestructible. Within the printed pages of our books, for years and years, she has been working unseen in silence and in darkness, drawing for us pictures of tree life of such loveliness as Rembrandt, prince of etchers, would have failed to imitate.

The accompanying drawing illustrates specimens of dendritic crystals, Figs. 1 and 3 being natural size. Fig. 2 is an enlargement, drawn from a micro-photograph of Fig. 1, kindly taken by Captain Barnes. The black mark shown in the magnified example appears to be the origin of this beautiful pattern.

The dendritic crystal is formed by chemical action set up by the accidental deposition of a minute fragment of copper upon the surface of paper during the processes of manufacture or of printing: the presence of the minute fragments of copper deposited being probably due to the wear and tear of the paper-making or the printing machinery, so far as the mechanism is built up of copper. The agency of manganese and the action of heat or of moisture in building up the dendritic crystal, tracing its arborescent characters black upon white on the surface, as well as in the very substance of the paper, must be left for a future article.

Unlike crystals from saline and other solutions, which may be rapidly formed upon the stage of the microscope "while you wait," as the signboard hath it, the dendritic crystal requires, as far as I have observed, rather more than twenty years before reaching its fullest development.

However, just as there is a firm in Chelsea who have been wresting from Nature one of the most hidden of her geological secrets, by transmuting a block of chalk into a block of marble in a few hours, it is among the possibilities of the near future that dendritic crystals may quickly be produced in the laboratory, rivaling, perhaps excelling, the specimens hitherto known.

I have never as yet seen a specimen in a book older than 1835, or younger than 1882. In the latter case, all the examples of the crystals were small in size, and their arborescent character was not nearly so well defined and luxuriant as in the volume aged threescore years.

It would be interesting to learn the experience of brother microscopists, and I would be glad to see reports in *Science-Gossip* from those whose experience differs from mine on the point.

A somewhat remarkable fact touching this subject is that, although I have examined scores of volumes of foreign origin, I have never yet been rewarded by the discovery of a single specimen. Never having seen an American or continental paper-making or printing machine, I know not whether the absence of crystals is due to there being no copper in their mechanism. I can hardly imagine any scheme of winnowing away foreign particles, or of pulp manipulation that would be so perfect as to wholly banish the tiny granule of copper, if any of that metal were in the make of the machine.

These crystals vary in size; the smallest are barely visible to the naked eye as, apparently, a minute black dot. A giant specimen would cover a threepenny piece. A good Coddington lens or a two-inch objective is indispensable for examination of the smaller specimens, but much of the beauty of the larger examples is manifest to the unaided eye. With a small lens one may go on a voyage of discovery among one's books in quest of crystalline beauty without any help from the microscope. Non-crystalline marks are hard in outline and of rigidly defined harshness and blackness at their edges, while the dendritic crystal that looks "blottesque" at half a yard's distance is found when closely examined to be fashioned with the utmost delicacy of filigree structure, as if indeed it had been designed in fairyland, and the master craftsman had made the pattern a blending of the beauty of tree life with the fantasy of the marine algæ.—*Science-Gossip.*

FIG. 1.—SPECTROSCOPIC APPARATUS OF THE MEUDON OBSERVATORY OF PHYSICAL ASTRONOMY.

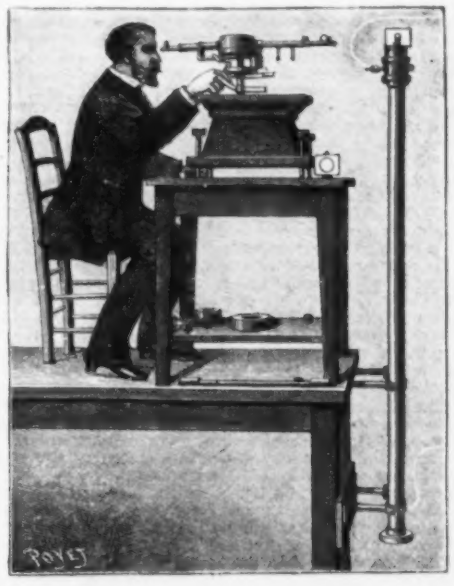


FIG. 2.—EXPERIMENTS WITH THE VERTICAL TUBE AND INCANDESCENT SPIRAL.

THE SPECTRA OF OXYGEN AT HIGH TEMPERATURES.

I SPOKE to the Academy at one of its former sessions about a method founded upon the use of electricity and adapted for raising gases under pressure to a very high temperature without perceptibly heating the receptacles containing them.

Before giving an account of the experiments made upon oxygen by means of this method, I shall first speak of those that preceded the latter and in which temperatures not exceeding about 300° were obtained by means of a row of gas lights acting directly upon the tube containing the oxygen gas.

The arrangement was as follows: A steel tube, 10 meters in length and lined internally with copper and closed at its extremities with glass (according to my usual method), was placed in an iron plate trough capable of receiving a sand bath. This trough was directly heated by 100 gas burners in a row.

The temperature of the tube was taken by means of thermometers connected metallicly with the tube.

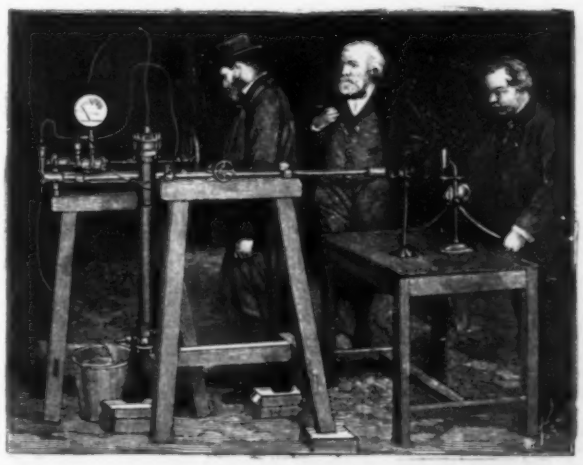


FIG. 3.—APPARATUS FOR HIGH PRESSURE EXPERIMENTS.

After introducing the oxygen at the desired pressure, and before the heating of the tube, there was obtained a good spectrum of the luminous source, whose pencil traversed the tube in such a way as to make it possible to estimate the modifications that the elevation of the temperature might bring about in the constitution of the absorption spectrum given by the gas.

The row of burners was lighted and the spectrum was observed in measure as the temperature rose along with the pressure.

When the experiment is properly conducted, the pressure of the gas at the finish (that is to say, when, the lights having been put out, the temperature has

become what it was at the start) returns to the degree at which it stood in the beginning.

In order to obtain this result, it is necessary that no loss of gas shall take place during the course of the experiment. One of the principal causes of such losses is due to the elongation of the bolts that connect the pieces of steel that hold the glass in place at the extremities of the tube. In order to destroy the effect of such elongation, brass cylinders, whose length has been so calculated as to compensate through their expansion for that of the bolts, have been placed between the heads of the latter and the disks. In this way the same degree of tightness is obtained at all temperatures.

The experiments were made with various pressures of oxygen gas, and showed that from the ordinary temperature up to about 300°, the bands and lines of the absorption spectrum of oxygen undergo no appreciable modification. But an entirely new phenomenon occurs. I refer to the very remarkable increase in transparency of the gaseous column with the elevation of the temperature, and which is revealed by a great increase in the brightness and limits of the spectrum, especially at the red end, and gives a much clearer perception of the spectral lines. I shall have occasion to revert to the theoretical consequences of this important fact.

In order to ascend higher in the scale of temperatures, I then began the use of the platinum tube with spiral rendered incandescent by the passage of a current. I shall not return to the general arrangements of the experiment, which have already been described. The incandescence of the spiral is so much the more difficult to obtain in proportion as the pressure of the gas is stronger.

In order to estimate the temperature to which the spiral is raised, various methods may be employed: (1) the thermo-electric couple; (2) observation of the increase of pressure of the gas produced by the passage of the current; (3) and, finally, the brightness and length of the spectrum given by the incandescent spiral, when the latter alone furnishes the light of the spectral apparatus.

The experiment is, therefore, thus arranged: The tube being placed in a vertical position, as I have said, one regulates the lamp that is to furnish the pencil to be analyzed after its passage into the tube, and afterward the spectral analyzer. A pressure is then given, and the constitution of the spectrum having been well noted, a current of a power appropriate to the temperature that it is desired to obtain is made to pass. The pressure immediately rises, and remains stationary when an equilibrium is established. The spectral phenomena are constantly watched and compared at the beginning and when the equilibrium is established.

In the experiments that I have made with a 2·10 meter tube and gaseous pressures running to 100 atmospheres, I have not noticed any perceptible modifications in the length of the spectrum that it was possible to observe.

In order to reach higher temperatures, I shall have to increase the power of my electric generators, and this is what I propose to do, but it must be remarked that from the view point of solar phenomena it is the exterior and middle parts of the coronal atmosphere that most interest me. It is these which, if they contained oxygen, would, before all the others, produce aqueous vapor, by reason of their lower temperature. Now, the temperatures of from 800 to 900 degrees that I have already obtained correspond to deep parts of the coronal atmosphere, and in these, as well as in those that are more external, and consequently colder, I can assert the absence of oxygen.—*J. Janssen, in La Nature.*

THE VENOM OF THE COBRA.

By C. A. MITCHELL, B.A. Oxon.

AMONG the most potent causes of death in India must be reckoned the bite of the cobra di-capello (*Naja tripudians*), the more so as the reputed native remedies, natural and artificial, all fail as antidotes to the venom when once introduced into the system.

Experiments made by various chemists have determined the chemical nature of the poison, though, owing to the difficulty and danger of procuring sufficient for the purpose, there are few quantitative results published.

To procure the poison, the reptile, which is firmly held by a native snake catcher or strapped down by the neck, is made to strike repeatedly at a large leaf, on which the venom from the fangs collects.

As first obtained it is a frothy liquid, varying in color from pale amber to yellow, and according to Dr. Wall occasionally colorless. Its specific gravity as compared with water is 1·058. It may be kept in a stoppered bottle for some months without material change, but eventually decomposes, giving off carbonic acid gas, and losing its toxic properties. Bacteria are found in abundance in the fresh liquid venom, as well as particles of epithelial matter, the latter being more noticeable after the liquid has been kept for a short time. The bacteria are derived from the saliva of the snake, and have been proved to add no additional virulence to the poison. When allowed to dry in the air it leaves a yellowish film, which breaks up into yellow granules of crystalline appearance, resembling particles of gum arabic. This residue preserves all the venomous properties of the fresh poison unchanged for years, as has been proved by experiments made on animals with venom that had been kept for over twenty years. Solution in glycerine is also found to be effective in preserving the toxic properties. The yellow granules are said to possess a sharp, acrid smell, though this was not noticeable in some which the writer examined, which had been kept for several years. On heating this old sample in a platinum basin it swelled up into a coke-like mass, giving off ammoniacal vapors, and on ignition left a slight ash in which sodium chloride was detected. The ash amounted to 1·5 per cent., calculated on the weight of the dried poison.

It has often been asserted that snake venom contains an animal alkaloid similar to the ptomaines found in putrefied animal matter, but this view is not supported by the majority of chemists. Though in some cases precipitates may be obtained with the ordinary test reagents, they are not distinctly crystalline as in the case of the alkaloids.

There is a class of complex substances containing a large percentage of nitrogen, and found chiefly in the animal world, to which the name of *proteids* or *albuminoid* bodies is given. Egg albumen, which constitues nearly the whole of the solids in the white of the egg, may be taken as a type of the proteid bodies, the average percentage composition of which is—

Oxygen, 21 to 23·5	Carbon 51·5 to 54·5.
Hydrogen, 7.	Sulphur, 3 to 2.
Nitrogen, 15 to 17.	Ash, variable.

When exposed to the action of acids, either mineral or such as are contained in the gastric juice, any animal albumen is converted into a substance known as *peptone*, which while of similar composition differs in several respects in its behavior toward reagents, and especially in its power of diffusing through a membrane such as parchment. There is also another albuminoid substance very similar to egg albumen in its chemical composition, but differing from it in being insoluble in pure water, which is known as *globulin*.

The complex nature of cobra venom has been noticed by many investigators, but Prof. Armstrong was the first to make a quantitative analysis of a small quantity of the liquid venom, sent to him by Sir J. Fayrer. He found that it left, on evaporation, a residue amounting to 28·28 per cent. of the weight taken, and that this residue, on analysis, gave the following percentage composition, after deducting the amount of ash:

Carbon	52·87
Hydrogen	7·05
Nitrogen	18·29
Oxygen and sulphur	21·33
	99·54

This closely corresponds to the general composition of albumens, but contains more nitrogen than egg albumen.

Prof. Weir Mitchell, in a long series of experiments, proved that there were two albuminoid bodies in the venom. By means of a parchment membrane floated on running water, on which the venom was placed, he succeeded in separating the two. The coagulable proteids were left on the membrane, while the dialyzable matter passed through. The substance deposited gave all the reactions of *globulin*. In the filtrate containing what had passed through the membrane was found a substance which could be precipitated but not coagulated by absolute alcohol, which property, among others, entitled it to be placed among the peptones.

He thus identified two classes of proteids:

1. A *globulin*—Coagulable and insoluble in pure water.

2. A *peptone*—Incoagulable by *brief* boiling and soluble in pure water.

There was a noticeable peculiarity about this venom peptone: although it did not coagulate at first on boiling, yet after some time it became coagulated, being apparently converted into a globulin. In this respect it differed from ordinary peptones. Careful experiments on animals proved that it was in the peptone that the toxic principle of the venom lay. Pedler succeeded in obtaining a yellow, semi-crystalline precipitate with this poisonous principle by platinic chloride, which differed, however, from that obtained with alkaloids in being less crystalline; and a similar result has been obtained by the present writer.

Owing to the similarity between the albuminoid substances in the venom and those in the blood, there is not much chance of finding an antidote which will neutralize the former without also injuring the latter. It has been found that the strength of the poison is not impaired by being heated to 70° C., and that death occurs as rapidly as when the unheated poison is used, but Fayrer and Wall noted that prolonged boiling completely destroyed its power. Alcohol, often spoken of as an antidote, has been shown to have absolutely no effect on the venom, and is only of use as a general stimulant to the system after a bite from a serpent. Mineral acids and the caustic alkalies neutralize it, but alum, though it delays, does not prevent death. The most active neutralizing agents yet known are potassium permanganate, ferric chloride, and iodine, especially the first; but owing to the rapidity with which the venom circulates through the system they could only be of local use, and would be of little avail once the poison were absorbed.

Take internally, the poison is as a general rule harmless, unless there be some abrasion by which it can get into the blood. The same applies also to its action on other mucous surfaces. Fayrer mentions a case where one of his assistants accidentally got some of the venom into his eye, with no worse result than temporary inflammation. Its primary action on the respiratory system is first to cause an increase in the number of respirations and then to diminish their number. Under its influence the blood corpuscles lose their shape and become fused together and the blood becomes incoagulable. Its action on the nervous system is, comparatively speaking, unimportant, and death occurs from paralysis of the respiratory centers or from inability of the blood corpuscles to do their work. The terrible local changes which occur after death from the bite of a rattlesnake are much less noticeable in the case of the cobra.

Among the most interesting properties of the venom is its action on other snakes. Sir Joseph Fayrer on more than one occasion caused a cobra to bite its own tail, which it would do very readily, but beyond the local wound it suffered no ill consequences. Cobras were found also to be immune against the bite of other cobras, but non-venomous snakes succumbed as rapidly as warm-blooded animals. The Indian viper, the *Daboia*, whose bite is as dreaded as that of the cobra, was found to be proof against the venom, and other species of poisonous snakes more or less so, apparently according to the strength of their own venom. It would thus seem that there is in the blood of the most poisonous snakes some principle which renders the venom innocuous, and in this direction may lie the possible discovery of an antidote.—*Knowledge.*

[Continued from SUPPLEMENT, No. 966, page 15444.]

MAN'S WORK IN DEFENSE OF PLANTS.

By JOSEPH F. JAMES, M.Sc., Assistant Pathologist, United States Department of Agriculture.

IT has long been known that there are certain forms of fungi which attack insects and cause their destruction. One of these has become famous as the vegetable caterpillar and has been variously described as an insect-vegetable and a vegetable-insect. The Chinese make use of this combination as a medicine, and it is one of the widely advertised curiosities of New Zealand. A much more common and familiar example of the action of fungi on insects can be seen every year in our own houses, where the common fly as winter approaches becomes attacked by a species of white mould. In the autumn we will often find fastened to the wall or to the window flies which are covered with a white down that examination proves to be a fungus. So far as I know, no advantage has been taken of this fact in spreading disease among these insects, but it is not so with other insects. It had been shown about 1857 by Pasteur that a disease affecting silkworms in Southern France was caused by a species of microscopic fungus, which finding access to the bodies of the caterpillars, multiplied there and caused great destruction. Active interest has of late years been taken in this subject and in some cases with a marked degree of success. Studies in France have been made to ascertain some method of destroying migratory locusts in Northern Africa and various destructive insects occurring in France, and in our own country to destroy the cabbage worm and chinch bug.

In France several species of fungi have been observed to attack insects, and the endeavor has been made to work out their life history, so that the best methods of dissemination may be found. One of the forms which has been worked out with most care is a species of *Isaria*, a sort of mould which attacks the common May bug. This insect has caused great loss in many parts of Europe and has appeared at intervals in enormous swarms. In all seasons its ravages are sufficient to cause great loss, and it has therefore become desirable to obtain some method of destroying it. The species of fungus above alluded to affects both the adult and the immature form. Upon both of these it forms white patches, which, at first appearing in isolated points, rapidly spread and soon cover the insect and the larvæ with a white felt work, thus effectually destroying it. In making any experiment to obtain the fungus for dissemination, its spores must first be obtained. These are cultivated upon gelatine or some other nutrient medium, taking care to have the culture pure. When once this is obtained it is transferred to some healthy insects and made to reproduce the disease. If this experiment be successful, the next endeavor is to obtain it in sufficient abundance to distribute it, and to that end breeding cages are kept where insects are inoculated with the germs, or else the diseased insects themselves are placed in fields where they are surrounded by healthy insects. These last becoming infected spread the disease to others, and so an epidemic is created. As yet all endeavors to spread an epidemic by means of spraying with an infusion of the diseased insects have failed. Experiments with migratory locusts in Africa have not been uniformly successful enough to justify any expectation of great results. Indeed, some have said the effort is impossible. It should be remembered, however, that the subject is in its infancy and that biologists are not yet in a position to say it will not eventually be possible.

Much more encouraging results of epidemic insect diseases have been reported from our own cowntry. In Illinois and Kansas, where the ravages of chinch bugs have been very great in some years, Profs. Forbes and Snow have made many experiments. In Kansas in 1891 $3,500 was appropriated to investigate the subject, and Prof. Snow has given a full report of his results. He found that at an expense of about $2,500 the farmers of Kansas were saved nearly $200,000. The results are sufficiently valuable to warrant continuation, and while the attempt to decry them has been made by some, it is not seemingly with sufficient reason.

Prof. Snow found three diseases affecting the insect. One he called the white grub fungus (*Sporotrichum globuliferum*); another the gray fungus (*Empusa aphidis*), and a third was a bacterial disease (*Micrococcus insectorum*). These affect the insect in various ways. Infection with white grub fungus had been carried over for the two preceding winters when experiments began in the spring of 1891. The farmers of Kansas had been informed early in April that the infection could be obtained if desired, and by the last week of April applications began to come in. In May the demand became so great that the supply threatened to give out, but a new supply being secured from an artificially infected wheat field, the diseased bugs were placed with healthy bugs in two large cases, in each of which were some 15,000 or 20,000. The insects were supplied with fresh food and in ten or twelve days the bottoms of the cages were thickly sprinkled with thousands of fungus-covered bugs of all ages. From this time on no difficulty was met with in supplying from twenty-five to one hundred and thirty-five applications per day.

After the infection has been introduced into a bug-infested field it generally begins to show itself in from one to four days. Its presence is shown by the bugs leaving their food plants and moving aimlessly about. In the course of another day the bugs become sluggish and seek protection from the sunlight and heat, generally congregating beneath clods or corn stalks or in some other more or less damp and shady spot. From the sixth to eighth day the first dead bugs are generally found. Under favorable conditions the fungus spreads with considerable rapidity. The more numerous the live bugs are in the field, the more rapidly the disease is communicated and the more malignant it becomes.

In one field it was observed that "although a few dead bugs were placed along the extreme south line, the disease spread of its own accord a quarter of a mile in a little over a week, killing the bugs before it as it went. So effective, also, was the same disease when placed in a corn field, that the ravages of the bugs were abruptly ended on the fourth day, when the whole brood was found upon the ground."

An account is given of the spread of an epidemic

among chinch bugs, in Minnesota. In this instance a field of wheat had been surrounded by boards placed close to the ground, so the insects could not crawl beneath them, and the upper edges were painted from time to time with tar. In addition to this, holes were bored in the ground six inches in diameter, close to the boards, and as fast as one hole became filled it was closed and another opened alongside. The disease appeared in the insects on the edges of the holes, which soon became so covered with fungus-covered bugs as to look as if whitewashed. From these holes the disease spread to the inclosed field, and the account reads like a history of a veritable plague. "The fields invaded by the disease afforded, upon closer inspection, a truly edifying spectacle to those not interested in the welfare of the chinch bugs. They looked quite panic-stricken, and moved about in a slow and dazed way, seeming to be badly scared; and well they might be! The victims of the fungus could be seen everywhere by the thousands; they had been slaughtered in all kinds of positions, but they were usually fastened to the blades and stems of the grass, or to the leaves of young clover. All showed plainly that their last and strong determination in life had been to hold on as long as possible: their legs well planted upon the substance where the bug happened to be; others had only their beaks inserted into it, and were dangling by it free in the air. But all showed the characteristic white mycelium threads and spores of the disease. Although almost exclusively attacking chinch bugs, the disease was not slow in slaughtering such small flies as found the society of such malodorous companions to their taste."

The bacterial disease was found to be worst during hot, dry weather, and to be in some instances more destructive than the white fungus disease. The former affects the intestinal tract of the insects, the bacteria multiplying to such a degree as to greatly distend the body. In this disease the bugs die in bunches, so that sometimes a cupful will be found in one spot. At the same time, it was noted that this bunching did not take place in uninfested fields.

The empusa disease (gray fungus) is also destructive at times. It works at the same time as the other two, but its victims are easily detected by the different color and larger appearance. There is an account upon record of an epidemic among flies in the District of Columbia, in which it is stated that large numbers of these insects were observed out of doors hanging to leaves of trees. Sometimes a single leaf had eight or ten specimens on the under surface.

Within the past two years numerous experiments have been made to ascertain some means of destroying the cabbage worm by fungous germs. Success has not been recorded in securing any method of disseminating the disease by spraying the germs upon the plants, but some experiments have been able to materially reduce the number of worms by placing powdered diseased insects upon infested cabbage heads. The experiments upon this subject are not concluded or conclusive.

We come now to another class of pests to plants, a class whose success in combating is a matter of less than ten years. These pests are the lowly organized forms of vegetable life known as fungi. The ordinary idea of a fungus is commonly expressed in a mushroom or a toadstool, but these forms are only examples of a class whose numbers and variety are far greater than the more conspicuous flowering plants. Leaving aside the common and larger forms with which every one is familiar, we find that the microscopic forms can be broadly separated into saprophytes and parasites. Saprophytes are those species which take their nourishment from dead or decaying matter; parasites, on the contrary, are those which fasten themselves upon living plants, and penetrating their soft tissues, take into themselves the elaborated materials of their hosts. The last are the ones with which we have to deal, inasmuch as they are man's most determined enemies. It is these parasites that cause rot in fruits, smut in grain, rust of grasses, moulds of many kinds, and the thousand and one forms of disease that make life a burden to the farmer, the gardener, and the florist. Fortunately, we are now in a position to say that many of these pests can be successfully prevented.

While the use of poisons against insects was the result of deliberate action upon the part of man, the use of similar agents against fungous enemies was the result of accident. In 1882 Millardet, a French professor, who had for some years been seeking a remedy for mildew of the grape, observed when passing through Medoc that along the roadside some vines had retained their leaves, while others were bare from the effects of mildew. Examining these vines, it was seen that the leaves were covered with a thin layer of a bluish-white substance. Inquiry of the steward of the chateau brought out the fact that the vines had been covered with a solution of sulphate of copper mixed with lime and water, to prevent the grapes being stolen. Marauders seeing the leaves covered with spots, hesitated to take the grapes for fear of being poisoned. With the effects of mildew in mind, Millardet at once thought that the copper solution was instrumental in retarding the progress of the disease. To ascertain the truth or falsity of this idea, he instituted experiments, and was so successful as to be able to announce in 1883 that he had discovered what seemed to be a remedy for the disease. It was two years later, however, in 1885, that he finally published a formula of a mixture which was to revolutionize the treatment of fungous diseases of plants. This mixture was at first called the "copper mixture of Gironde," because it was first observed along the Gironde River. It is now almost universally called in this country Bordeaux mixture.

As soon as news of the new remedy reached this country the Department of Agriculture began a series of experiments which has been carried on up to the present time. Now, scarcely a single publication upon fungous diseases of plants appears in which there is not mention of Bordeaux mixture.

At first it was prepared so as to form a thick paste and it was laboriously sprinkled upon the vines by means of a whisk broom. This method has long since given way to the easier and more certain method of distributing by a spraying pump. Fortunately the use of Paris green in liquid form to destroy the potato beetle had prepared the way for distributing the liquid Bordeaux mixture. It only needed a few years of experimentation to secure the almost perfect apparatus which is known as the knapsack pump, and the general features of which have already been described.

We need not here enumerate the many changes which have been made in methods of making and using Bordeaux mixture. It must suffice to say that the most approved method now is to dissolve 6 pounds of copper sulphate in about 16 gallons of water; in another vessel slake 4 pounds of strong, fresh lime, using a little water at a time until the lime is all slaked, and then diluting with 6 gallons of water, so as to form a thin milk. This milk of lime is then poured into the solution of copper through a strainer made of coarse cloth, and the mixture is ready for use. The copper sulphate is best dissolved by placing it in a coarse-meshed bag and then suspending it in water. The solution may be diluted so as to make 45 gallons instead of 22, and in many diseases this gives just as good results.

While Bordeaux mixture is probably more extensively used than any other fungicide, there are many other preparations. One of these is known as ammoniacal solution of copper carbonate and is a combination of copper carbonate, ammonia and water. It is prepared by dissolving 5 ounces of copper carbonate in a wooden pail with sufficient water to make a thick paste. Three pints of ammonia, or enough to dissolve the carbonate, is added, and the whole diluted with 45 gallons of water.

Both of these preparations are sprayed upon the trees of plants infested with fungi by an ordinary knapsack spraying pump or a larger, cart, machine. They are used in combating diseases of all sorts of orchard and small fruits and many vegetables. Blight or rot of the potato, for example, can be prevented entirely by using Bordeaux mixture. Sulphur is another useful and an old-time remedy, and it will destroy mildew of roses and other house plants. It may be either sprinkled in a dry form upon the leaves or in hothouses be spread upon the pipes and the fumes be allowed to fill the air. Potatoes are frequently affected by "scab," a fungous disease, the spores of which get beneath the skin of the tubers, forming there a corky layer which finally ruptures the skin and gives rise to rough-edged, pock-like areas. Several of these may unite, and the whole skin may thus become diseased. Experiments have shown that the disease can be combated and entirely prevented by a little care and attention. Inasmuch as the germs of the disease lie dormant in the soil for some time, it is better not to plant in soil which has produced scabby crops. The seed potatoes before planting should be immersed in a solution of corrosive sublimate. This is made by dissolving two and one quarter ounces of the sublimate in about two gallons of hot water, and after an interval of 10 or 12 hours, diluting this with water so as to make about 15 gallons. In this 15-gallon solution the potatoes to be planted should be left for about one and one-half hours. They are then taken out, cut and planted as usual. A barrel is a convenient receptacle for the solution. The potatoes to be treated should be washed if very dirty, and then be placed in a loosely woven sack, like a coffee sack. This is then suspended in the liquid for the required time. Of course, all the treated tubers should be planted, for corrosive sublimate is a virulent poison when taken internally. While destroying the germs of the disease, it does not affect the growth of the potatoes.

It would be tedious to mention the many diseases whose ravages have been overcome by the use of these and other fungisides. It must suffice to say that while there are of course some whose growth it has been impossible to prevent, there are many others that have been so successfully combated that the labors of the farmer have been rendered much more remunerative. As irrigation in the Western States has made the farmer independent of the rainfall, so in other places the discovery of fungisides has enabled him to cope with insidious enemies and to plant his crops without the fear of losing all his work and all his crop through the action of insect or fungous foes.

Among the latest methods of protection of plants is that relating to the artificial production of clouds for the prevention of frost. In many parts of this country spring frosts are among the things which blast the hopes of the fruit grower at the last moment, and when everything had previously seemed favorable. Every one knows that there is much less likelihood of a frost on a cloudy than on a clear night; and it was this, perhaps, which led to the idea of producing artificial clouds, and thus preventing the damage by frost. Although there have been successful spasmodic efforts made in this country, the subject has been systematically investigated by a Finn. Finland, it appears, suffers several times in every century from disastrous frosts occurring during the growing season, often in July and August. When the frosts occur famine follows. Experiments developed the fact that frosts could be prevented by the formation of artificial clouds, or by creating artificial currents of air, or perhaps by the use of both combined. For this purpose special "frost torches" were made. These consist of tubes of well dried peaty mud, and kindling cylinders to be inserted into them. The peaty tubes are about 5 inches long and 3¼ inches in diameter, with an opening of about 1⅛ inches in the center. If well dried, they may be placed in the field ready for use and left until needed, since rain affects their surfaces only and they soon dry out. The kindling cylinder is three-quarters of an inch high, of a diameter to fit into the peaty or mud tube, and having an opening of two-fifths of an inch. "When moistened with a little petroleum the kindling cylinder is put a little more than its length into the sloping mud tube and kindled. At first it burns with a flame, but begins soon to produce so much heat that the mud tube begins to carbonize." The result is a dense smoke or smudge which serves as an artificial cloud. The field to be sheltered must be carefully examined, and if there is likely to be a current of air from a piece of neighboring higher land, this must be cut off by torches placed about six feet apart. If the field lies in the open, torches must be placed all round it about ten feet apart and along the borders of ditches about fifty feet from each other. The number of torches required is from 100 to 150 per acre, and these will cost from $6 to $9. With a favorably situated field, on sloping and well drained land or surrounded by forests or hills without intervening level fields, the number of torches can be reduced ten or twenty per cent.

In this country it is said that on the eastern shore of Lake Michigan one large peach orchard was protected from frost by making a dense smoke by burning tar torches. One requisite for success is the absence of wind, for if this be strong the smudge will be blown away, and so cannot act as a protection to the plants.

From the methods described it is evident that man has attained considerable success in protecting his plants from enemies of various kinds. The insect world and the fungous world are being conquered, and the endeavor now is to conquer the elements. With an increased knowledge of meteorological conditions, this does not seem to be an impossibility. There is already an ability to predict the probable occurrence of cold waves and the probable oncoming of frosts. Still more than this. From the astro-physical laboratory in Washington, only two years old, it has been announced that forecasts of the weather for hours and for days can be made. These forecasts not from a study of terrestrial, but of celestial features. From, indeed, a study of the solar spectrum. The connection between the sun and cereal crops on the earth has been considered fanciful; but statistics have shown that there is some as yet unknown relation between the two. This connection seems now in a fair way to be unraveled. When man shall have succeeded in harnessing the sun as he has the lightning, and controlling the air as he has the earth, then in truth will he have the whole earth for his heritage.

THE TAWNY OWL.

By HARRY F. WITHERBY.

THE sun has set, and the moon, just rising above the trees, casts dense shadows across our path as we are walking along a somber glade in the forest. All nature is hushed, save for the occasional drone of a beetle, or flit of a moth, when suddenly, from a distant clump of trees, a loud cry sounds forth. We crouch down and remain perfectly still; then the melancholy notes are repeated, and a little further off an answering cry is heard. The sound gradually draws nearer, until at length it is loudly uttered just over our heads, and looking up into the branches above us we catch a glimpse, by the light from the moon, of a tawny owl gliding through the trees.

This bird's cry, or rather hoot, resembles the syllables whoo-whoo-whooo-oo, the first two being very short, while the next is prolonged and finishes with a short "oo." It is a very mellow sound; for, except occasionally, it is not heard to screech. One of its scientific synonyms is *Ulula aluco*, being derived from the Latin, *ululare*, to cry like a wolf, and this word partially imitates both the cry of the wolf and of this owl; *Strix aluco* is perhaps the more correct name.

The tawny owl is also called the brown owl and wood owl, the first two titles being descriptive of its tawny brown plumage, the last of its haunts. A thickly-wooded district in England or Wales is almost sure to have its brown owls. It is also fairly common in the south of Scotland, but in Ireland it has not yet been found.

To those who do not care to roam through the woods at night this bird is, no doubt, little known, for it is not often seen in the daytime. All day it hides in the recesses of the forest, perhaps in the hole of a tree; or sometimes it may be detected seated on a branch nearly touching an old squirrel's nest, and it then requires a sharp eye to distinguish it from the nest itself. Strong light affects the sight of this bird exceedingly, rendering it almost blind, and it seems as much at a loss when abroad in the daytime as a jay would be at night. It screws up its eyes and blinks in the most curious manner, and on being disturbed, it flies about in an aimless way, and thus attracts the attention of other birds, and by no means pleasantly; for in a very few moments after it has been frightened from its roosting place, a jay or missel thrush will find it out and begin to screech and hiss at it. These birds quickly increase in numbers, and presently the owl will be surrounded by a "mobbing flock," all keeping, however, at a respectful distance from the object of their hatred, for every now and then the owl will make a dart at one of his tormentors, and snap his beak loudly as the smaller bird dodges aside.

The plumage of the tawny owl varies considerably in shade of color, according to the age and sex of the specimen. The female bird is always larger, and usually much more tawny than the male, and indeed this fact led to its once being considered a distinct species. In the male, the back and head and the upper sides of the wings and tail are a brownish gray of various shades, with several large white spots on the wing coverts. The under parts are dull white in ground color, with brown markings.

The eyes are very large and perfectly black. They are surrounded, as it were, by a disk of bristly feathers, which gives the bird's face a very solemn and staring appearance. The bill, which is surrounded with bristles, is large and powerful. The upper mandible is longer than the lower, and being curved downward at the end, it forms an excellent hook, with which the bird tears and carries its prey. The legs of the tawny owl are covered with short white feathers, and the feet have four toes, two pointing backward and two forward. These are armed with strong curved claws, and the bird having an exceedingly powerful grasp, the curved claws are an additional help to it in securing its prey.

The plumage is abundant, and so very soft that the bird flies in perfect silence and steals unawares on its prey. Voles, rats, mice, shrews, moles, squirrels, small birds and even insects are pounced upon by this prowler of the night. The prey is seized with the feet, and borne, either in the beak or claws, to a place of safety. The owl then devours its entire—bones, fur or feathers—and by a beautiful economy of nature, when the digestible portion is absorbed, the bird rejects the remainder in the form of a pellet, which is vomited up.

These pellets, gray in color, are about the shape and size of an emperor moth's cocoon, and when macerated in water, they are found to contain often three or more entire skeletons of mice, together with the fur. They may be picked up in open ground, or under a tree frequented by owls.

This beautiful and most useful bird is still much

persecuted by the gamekeeper and farmer, notwithstanding all that has been said in its favor. Occasionally the tawny owl may take a young rabbit; but why should we grudge him this when we consider the vast numbers of mice and rats that he consumes? Gamekeepers have said that they have seen this owl among their young pheasants, and have therefore shot it; but it has been proved more than once by dissection that the bird was merely catching the mice which were feeding on the corn left by the young pheasants.

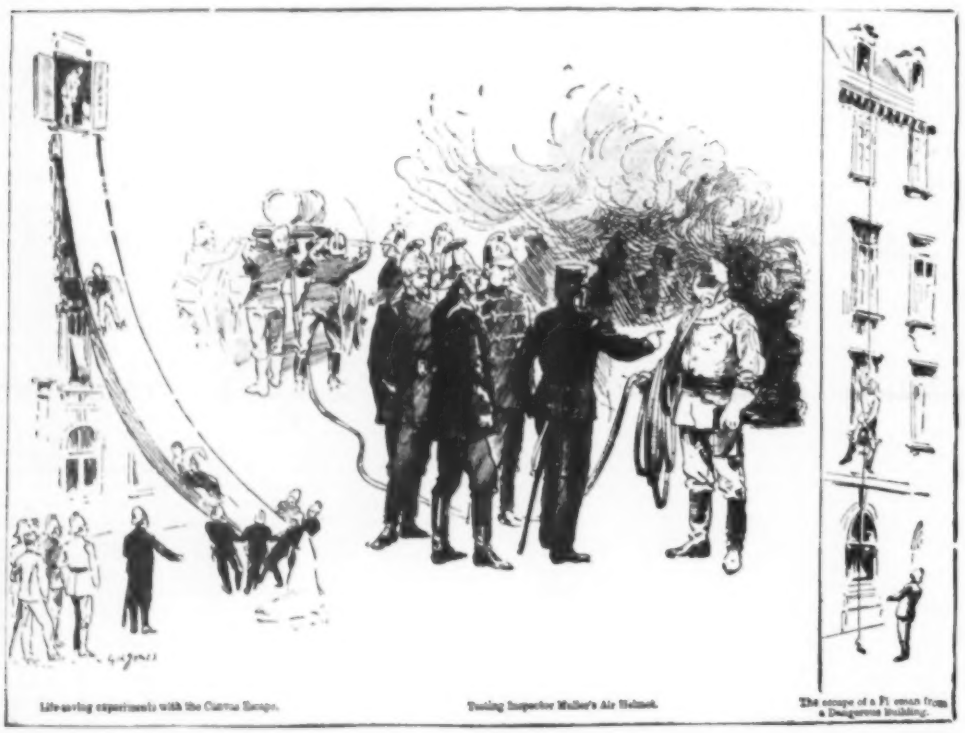
The usual nesting place of this owl is a hollow tree, but sometimes the disused nest of a crow, magpie or jackdaw is selected, and we once found their eggs in the top of a fir tree, the branches of which were naturally interwoven, thus forming a sort of platform. These birds make no nest, and if a hole in a tree is chosen, the eggs are laid upon the wood dust at the bottom of the hole, while a quantity of pellets and a few feathers are usually found intermixed with the wood dust. They resort to the same nesting place year after year. The eggs are nearly round and perfectly white and from three to five are laid. The bird commences to sit as soon as the first egg is laid, so that there is often a considerable difference in the age of the young ones found in the same nest. They are hatched in three weeks, and are blind for the first few days.

An owlet of a few weeks old is a most grotesque object. It is covered all over with grayish down, and out of this downy ball appear two large eyes and a beak. If one should look into the nest, the owlets snap their beaks and hiss courageously. However, until they begin to get their feathers the snapping bill has no strength, and the finger may be put harmlessly into the mouth. These birds are very easily reared and become very tame in captivity, although treacherous at times as they get older. They may be fed on almost any uncooked flesh, but young birds and mice are especially relished.

Although the tawny owl can live for a long time without water, he, nevertheless, enjoys a bath immensely. Standing in the water, he spreads out his wings and tail and throws it in showers all over himself. He emerges from his bath the very picture of bedraggled misery, but soon dries himself by vigorous pluming.

The old birds defend their young very courageously. A man we know was savagely attacked by the parent bird while climbing a tree with the intention of taking some owlets. Hearing his approach, the owl flew out of her nest and struck the unfortunate man with both feet, piercing, with the long sharp claw, one of his eyes, so that he lost the sight of it, and all but inflicting the same injury on the other eye.

Should the hoot of the tawny owl be heard no more, our woods would lose one of their chief charms by night. If this useful bird is exterminated, the farmer will soon find that he has lost one of his best friends.—*Science-Gossip.*


Life-saving experiments with the Canvas Sleeve.
Testing Inspector Muller's Air Helmet.
The escape of a Fireman from a Dangerous Building.

BRITISH FIREMEN IN VIENNA—THE VISIT TO THE CENTRAL FIRE STATION IN THE AM HOF.

ENGLISH FIREMEN IN VIENNA.

AFTER being feted at every leading railway station between Bodenbach, on the Austrian frontier, and the Kaiserstadt, the eleven representatives of the English Fire Brigade Union spent last Thursday visiting several of the volunteer fire stations in the suburbs. Friday was reserved as the great event day at the Central Fire Station in the ancient Am Hof of Vienna. Punctually at the stroke of ten in the morning, the English captains appeared, presenting a brave array in their bright, massive helmets. They were cordially welcomed by Director Zier, the chief of the Vienna Fire Brigade. There was a huge crowd in the Am Hof, constrained within proper limits by a full staff of police. The Viennese rightly consider their firemen an exceedingly smart and dashing lot, and this smartness and dash the firemen were keen on maintaining during the display before their English brethren.

Commander Zier, standing with his orderly in front of the Central Station, figuratively pressed the button at 10:5 A.M. The change was somewhat startling. The Central is rich in fire-extinguishing appliances, and manual after manual, water barrel cart after water barrel cart, hose carts, steamer after steamer, shot out the gates and dashed off. The onlookers got out of the way without any police assistance. In less than five minutes the Central had emptied itself of its first and second fire services, and also the two reserves. The big telescope ladder was also under way. Five minutes passed and the manuals dashed up again.

In imagination the Central Offices were on fire. The Vienna firemen were soon scaling the building front with cat-like agility. These climbers carry *en banderole* about 70 ft. of a finely spun rope called the "Rescue Line."

It is so coiled that it pays out rapidly when necessary. To one line thus paid out was tied the rescue canvas shoot, and when this was raised and fixed to the window front, the fireman-rescuer shot the occupants of the room, one after another, safely to the ground. The height was about 45 ft. A sensational scene followed, when, at the command of a bugle call, Commander Zier ordered all firemen away from the building as dangerous. It was a hurried *sauve qui peut*. One daring fellow left his "delivery" on the roof, 70 ft. from the pavement, paid rapidly out his "life line," fastened one end firmly to a skylight bar, and came down hand under hand.

The inspection of the station followed this interesting and instructive display. The horses number 100, and cost £45 each—a big price in a country where horseflesh is so cheap. The telegraphic service is excellent, and every fireman can use the Morse instrument.

But the appliance most interesting to the English visitors was the chamois skin helmet and air life tube for use in cellars or underground buildings when on fire. It is the invention of Chief Inspector Muller, second in command of the Vienna Fire Brigade. The air tube is spirally protected and cannot bend or split; the end is attached to a manual, and the air pumped through. The helmet is securely fastened to the shoulders by two thin chains passed under the armpits. It was subjected to a rigid test in the court of the Central Fire Station. The fireproof cellar which the fireman thus equipped entered was full of the densest smoke. The English captains who essayed to accompany him were quickly driven back on descending the staircase itself.

Chief Inspector Muller, after the trial was over, was warmly congratulated on the simplicity and great utility of this air helmet. At the luncheon immediately afterward, Capt. Dyson, of Windsor, indorsed the sentiments of all present when, in proposing the toast of Commander Zier, he said that the Vienna Fire Brigade was the most complete and efficient of any they had yet inspected on the Continent. This opinion has not only gratified the firemen chiefs, but also the Viennese themselves.—*London Daily Graphic.*

JEREZ AND ITS VINES.

IF Jerez offers little attraction to the tourist in Spain in the way of magnificent churches and ancient castles, it is, on the other hand, much more Spanish than the majority of the big cities in the peninsula. But for its famous bodegas and vineyards, Jerez de la Frontera (so called to distinguish it from quite another place, Jerez le los Caballeros) would be wholly passed over by travelers; and as it is, English is a dead language at the principal fonda—a certain sign that English visitors are few and far between. The first impression of Jerez is that it is a clean and exceedingly pretty city, with its whitewashed towers, walled fortresses, and quaint Moorish architecture; a few days' stay will serve to confirm that impression. Like all other cities in the south of Spain, the comparatively modern method of locomotion by four-wheeled carriages was a contingency not anticipated by the original architects. The streets are for the most part not only extremely narrow, but badly paved with huge and uneven stones of the size of full-grown cabbages. The most, and in fact the only, comfortable way of getting about is on foot, for whether on mules, horses, or in a carriage, the inevitable jolting will be a thing to remember for a quarter of a century afterward.

The history of Jerez goes far back into the remote periods of antiquity. Indeed, legends are its only annals. And of its history, we may use the words which Fuller says of the pyramids: "It is so far doting in age as to have forgotten the very name of its founders;" nevertheless, in spite of the fact that

> "The Grecian mound, the Roman urn,
> Are silent when we call;
> Yet still the purple grapes return
> And cluster on the wall."

Equally remote, too, and buried in the ashes of a prehistoric past, is the origin of the cultivation of the vine at Jerez. One of the earliest references occurs in the original chart of grant—still preserved at Jerez—signed by Alfonso the Learned, who wrested the place from the Moors in 1264, and who peopled the place with forty hidalgos, "the *souches* of the present Jerezana nobility." He grants to hold in feud, "houses, 6 aranzadas (equal to acres, but varying in different localities) of vineyards, 2 of huerta (or orchards), 15 of olive grounds, 6 yugados (the area which twelve bullocks can plow in a day) for corn; and, besides, 200 maravedis of the king's privy purse."

In the town itself the bodegas are the chief attraction, which even the most truculent teetotaler will not attempt to resist. Each of these immense establishments deserves an independent article, even if only on account of the courtesy with which properly accredited visitors are shown around and permitted to test the various samples of sherry. But the finest, as they are probably the oldest—they have been in possession of the present family since the earlier part of the last century—are those of Senor Pedro Domecq, to whom the present writer is indebted for many kindnesses. Possibly it was from one of these old-established bodegas that the "Sherris sack from whence comes valour," as Sir John Falstaff, who knew its merits, puts it, may have found its way into England, where it was well known and much appreciated early in the sixteenth century. At the end of that period its popularity had greatly increased, and large quantities were brought home by those who, under Essex, sacked Cadiz in 1596. Indeed, the term "sherris sack" is simply the English of the name "Seco de Jerez," by which it is still known in Spain.

To witness sherry making from its inception to the final stage—that of exportation—is a course of study which few Englishmen have gone through. The good luck which attended the present writer in his wanderings in Spain was equally good in this respect, for the harvest begins and ends within a fortnight. To witness the harvest it is necessary to start early from the city, for not only do the peasants cease working for two or three hours in the middle of the day, but "those rayes," in the words of John Howell, "that do but warm you in England, do roast you here; those beams that irradiate only, and gild your honeysuckled fields, do here scorch and parch the chinky gaping soyle, and put too many wrinkles upon the face of your common mother."

Punctually, therefore, at 7 a. m., Senor Domecq's son, Senor Jose de Domecq y de Villaviecnclo, with a couple of friends, drove up to the Fonda de Jerez, in Calle de las Naranjas, and within a few minutes we were doing an irregular and violent seesaw—"the remembrance of which causes pain"—over those fearful roads to the vineyards. The Domecq vineyards, four in number, are the largest in that part of Spain. The largest one covers an area of about 500 acres, and is rather more than an hour's drive from the city. These vast estates cost about 25,000 dollars per annum to work, the average wages of a laborer being a *peseta* (about 10*d.*) per day, and it is quite certain that the employer does not get more than his peseta's worth. The average annual produce of these vineyards is placed at about 800 vats; of course, the whole of these vats are not of prime quality, while an evaporation at the rate of at least 10 per cent. per annum still further reduces the quantity of the first-class article. There are, of course, good and bad districts; the finest of all being the "Pago de Macharnudo," from which is annually obtained from 2,000 to 2,500 botas of exquisite wine, and from which is derived the well-known "Domecq pure grape brandy."

The varieties of grapes known in and around Jerez are almost as numerous as those of the rose and chrysanthemum in this country. So far as the present writer knows, there is no treatise in English on the Spanish vines, and the best treatises in Spanish are those of Rojvas Clemente, "Ensayo sobre las Variedades de la Vid" (Madrid, 1807), and the two works of Tablada, "Tratado de Vinificacion," 1850, and the "Cultivo de la Vid." Before dealing with a few of the more important varieties, it will be interesting to mention a few statistics in proof of the greatly increasing trade in sherry. In 1841 there were imported from Jerez 14,773 butts of 30 arrobas* each, value £440,000; in 1860 there were 30,725 butts, value £1,400,000; in 1862, 34,314 butts; and in 1883, 34,314 butts. Senor Domecq informs me that about forty varieties of grapes are now grown in and around Jerez, at the head of which comes the "Palomino blanco"—probably the same as the "Listan" of San Lucar—which covers nine-tenths of the *vinas albarizas*, and which is the earliest of the better sorts. The "Mantuo castellano" and "Mantuo de pilas" are the best of the later sorts, which are most generally grown in the *vinas de arenas*. The *albariza* and the *arena*, it should be mentioned, indicate the nature of the soil, the former being a whitish clay mixed with carbonate of lime and silex, and is the best for grape growing; while the *arena* is little better than sand, but it is very productive, although the wine is of an inferior quality.

Other varieties which are more or less extensively grown are the "Albillo," the "Mollar," the "Perruno," and the "Canocazo" (which are among the most aromatic of the Jerez wines). The famous varieties, "Pedro Ximenez" and "Moscatel," are the two sweetest varieties grown in Jerez; the grape is left exposed to the sun for from ten to twelve days, and thus become sun raisins or pasas. The "Pedro Ximenez" is dark, and its flavor that of the natural grape. The "Moscatel" is even sweeter than the last named, and

* The arroba is a Moorish name, and a dry measure, although used for liquids; it contains a quarter of a hundredweight; 30 arrobas go to a bota or butt.

is still darker. The "Pedro Ximenez" came originally from Madeira, and was planted on the Rhine, from whence, between two and three centuries ago, it was brought by a certain Peter Simon to Malaga, and has since become extensively cultivated over the south of Spain. From this variety is obtained the luscious sweet wine called "Pajarete," which is extremely costly, "as it is much used in the rearing and maturation of young sherry wines." Mention may also be made of the "Tintilla" and "Alicante" varieties, as being grown in many places and for special purposes; and the other sorts on our list include the "Beba," the "Calona," the "Ferrar," the "Vigiriega," the "Jaen," the "Rey," and the "Almunecar." Naturally the quality of the wine depends partly on the variety of the grape and on the soil, and it has been found that certain varieties do better than others in a poor soil.

The cultivation of the vine at Jerez is rather one of unremitting attention than of anything else. The vines are allowed to bear fruit when about five years old, and with proper attention they will continue to be productive for nearly half a century; indeed, there are many on the Domecq estate which have attained to over sixty years of age, and it is found that whereas the produce from the older bushes is smaller, the quality in much of the wine is superior. The plants are rarely allowed to grow to a greater height than three feet. Pruning, trenching, and a constant watch to see that insect pests do not establish a hold, are the most important duties when a vineyard is in thorough-going order.

It is not until the harvest time arrives that excitement prevails; but however simple this process may appear, it involves much care and forethought. When ripe the bunches are picked and spread out for some days on matting, the unripe berries being separated, and subjected to a longer exposure to the sun; while the over-ripe ones are sprinkled with a little lime, "by

THE WEEPING BIRD CHERRY.
(*Cerasus Padus bracteosa.*)
—*The Gardeners' Magazine.*

which the watery and acetous particles are absorbed and corrected." After the grapes are properly dried they are taken to the *lagar*, or wine-pressing sheds. It is at this point that the conservatism of Spanish wine making is most apparent; for the first process of extracting the juice is precisely the same as that in vogue two, three, and perhaps four or more thousand years ago, namely, by being trampled under feet. It is not because the Spaniards have no wish to keep pace with the onward movement of events, but because every attempt at hydraulic and other means of pressure has failed to work as effectively as the old one. The wine pressers are, it is true, scantily clad, but the work is not done, as it once was, with the naked feet, but with specially-made boots, the soles of which are thickly studded with large, sharp, angular nails, which do the work most effectively. After this first process, what remains is subjected to second and third pressings, which are now done by hydraulic power. The wine pressers work in couples, each pair having a huge slanting trough to itself. The juice is now put into botas or small wine leather bottles, where it undergoes fermentation, and where all impurities subside. The fermentation usually takes four or five months, and when the juice becomes wine it is racked from the lees, and left to settle for four or five years.

Such, then, is a brief account of the wine making at Jerez de la Frontera. It is not offered as one of the many panaceas for the present agricultural depression, but the process possesses many points of very great interest to horticulturists, who might learn many lessons of importance by a visit to the famous and ancient vineyards of Spain.—*W. Roberts, in The Gardeners' Chronicle.*

BEGONIA PLATANÆFOLIA DECORA.

AN extremely beautiful form of this distinct free-growing South American species, the leaves large, irregularly palmate with bronzy green veins, and variegated with silvery white. A valuable addition to the

BEGONIA PLATANÆFOLIA DECORA.

list of ornamental leaved begonias. F.C.C., R.H.S., May 23. M. Linden.

HYBRIDS OF NARCISSUS TRIANDRUS.

Two of the most noticeable of these hybrids are now figured. Snowdrop, which I value as one of the best of all my seedlings so far, is from *N. cernuus* by pollen of the Major or Glenan Island variety of triandrus. The flower is large, measuring, when at its best, nearly two inches in length of corona. The perianth extends quite horizontally. The scape is commonly two-flowered, the color is a uniform pure white. The union of this same variety of *N. triandrus* with the well-known *N. poeticus ornatus* has produced a very characteristic and pretty narcissus. In this case also the scape is two or sometimes three flowered; the cup, of a pale citron color, is considerably shorter than in the average of *N. triandrus*; the perianth is white and either horizontal or reflexed; the segments are in some flowers broad and overlapping, in others narrower. The whole plant is very elegant. It is evident that *N. triandrus* will cross with every fertile variety of narcissus. I add a list of the kinds from which or by which (often both ways) seedlings have been flowered here: *N.* Emperor, Empress, Horsefieldi, Yellow Ajax in variety, *cernuus*, *albicans*, *moschatus* of the Pyrenees, *poeticus*, *monophyllus*, *corbularia* in variety, Leedsi. I have also seedlings between *N. jonquilla* and *N. juncifolius* and

NARCISSUS SNOWDROP.

N. TRIANDRUS × N. POETICUS ORNATUS.

triandrus, expecting them to yield flowers identical with the so-ca led *N. triandrus pulchellus*, but they are delicate and difficult to bring to maturity. It is worthy of remark that *N. triandrus* has the peculiarity of eliminating all red coloring matter from narcissi with which it is cross-fertilized, none, *e. g.*, of the hybrids which I have raised between it and the very red-cupped *N. p. poetarum* showing any trace of red in the corona.—*G. H. Engleheart, in The Gardeners' Magazine.*

ECONOMIC BOTANY.

By EDSON S. BASTIN, A.M.

ECONOMIC botany may be briefly defined as botany applied to useful ends, or as the study of plants in relation to the wants of mankind. That plants do stand in very close relation to human happiness and welfare, and even to the necessities of man's existence, is a fact so obvious that it scarcely needs to be dwelt upon. We depend upon the vegetable world for the greater share of our food, and, if we take into account the fact that the animals we employ for food all either directly or indirectly obtain sustenance from plants, we may say that we are absolutely dependent upon them for the essentials of our diet and would quickly perish without them.

We depend scarcely less upon them for our clothing and building materials, and for numberless other things upon which our comfort and well-being depend.

We also draw from the vegetable world the greater part of the medicines we employ in healing our diseases. There are also the best of reasons for believing that if it were not for the chemical activity of plants in breaking up the carbon dioxide so constantly exhaled into the atmosphere from the lungs of animals, from the chimney throats of our factories and private dwellings, and from the processes of decay that go on about us everywhere; if it were not for this and the restoration of pure oxygen to the atmosphere that the chlorophyl plants are all the time accomplishing, the atmosphere itself would soon become so vitiated that it could no longer sustain the higher forms of animal life, and we should perish from the earth.

In still another respect we are dependent on this world of plants. If it were not for the bacteria and fungi, those despised and very much dreaded parasitic and saprophytic organisms whose work is largely that of tearing down and restoring to the mineral kingdom, and so to available forms for growth, dead organic bodies, the earth would soon be piled so high with corpses that there would be neither room nor sustenance for living beings.

It is largely on account of these relations between plants and human welfare that botany, the science of plants, has grown up. True, superstition has had something to do with its beginnings, as it has with those of other sciences, chemistry and astronomy, for example. The superstitious belief in a philosopher's stone stimulated the research which gathered together

many important facts that have greatly helped to lay the foundation of chemical science. Likewise it was a superstition that the stars sway the destinies of men, but it stimulated observation of the heavenly bodies and aided to accumulate the facts on which rests the superstructure of modern astronomy. So, in botany, for example, the absurd doctrine of signatures, which so long prevailed in medicine, led to a decided extension of our knowledge of plants, and so helped build a science of botany.

We have many things to blame superstition for; as a general thing, the world has no use for it, but it is well to recognize the fact that it has not always been wholly evil in its effects.

But the foremost cause of the development of botany, in its earlier years at least, was *utility*.

Some knowledge of plants was so much one of man's necessities—to know what plants were useful and what ones dangerous—that long before he reached the stage of mental development when science in any proper sense was possible, a considerable body of facts were got together to build upon when the proper time should come. Thus, as we are well aware, the use and cultivation for food, medicine or textile materials of many of the plants we value most extends far back of the period when written human history began. This is the case with wheat, maize, barley, millet, sorghum, the opium poppy, cotton, the banana, apricot, orange, melon, pumpkin, bean, pea, manioc, olive, rice, peach, sweet potato and flax.

In many of these instances, in fact, as with maize, we are absolutely ignorant of the wild plant from which the cultivated form is derived. In some cases, most likely, the changes brought about by the ages on ages of cultivation are so great that we are now unable to identify the cultivated with the wild parental form; it has, in fact, been developed into a distinct species. This, perhaps, is the case with wheat. In other instances, probably the parental form has perished altogether, as De Candolle believed to be the case with maize.

In one sense, then, botany *began* as economic botany, began with the utilities in far-off times, and since then, until comparatively recent times, has chiefly occupied itself with them. But when man reached the age of reason, and science in the proper sense of the term became a possibility, plants came to be studied, not solely or chiefly with refe ence to their uses, but from a desire to understand what they were in themselves, what were their relations to each other, to the mineral world, on the one hand, and to the other half of the organic world, on the other. The passion to know plants took possession of some men, as that to know the mec anism of the heavens or the structure and development of the earth possessed others, and so scientific botany became a reality.

This new development of botany may be said to have begun about three centuries ago, with the work of the Florentine, Cæsalpinus, but it made only slow progress until about a century later, when the Englishman, John Ray, in his, "Methodus Plantarum," laid the first really rational basis for plant classification. From this time on, through the work of Tournefort, Linnæus, Jussieu, A. P. De Candolle, Endlicher, Lindley, Hooker, Bentham, Alphonse De Candolle and Gray, systematic botany has made rapid and splendid progress.

Necessarily, owing to the later development of the compound microscope and that of chemical science, the growth of physiological botany was more retarded. Although in ancient times some crude notions existed about the sexuality of plants, the functions of stamens and pistils do not appear to have been understood until Grew explained them in 1676. From this time until 1823 no great progress was made in this branch. In this year, Amici discovered the pollen tubes, and a little later Robert Brown traced them to the nucellus of the ovule. Since then the embryology of plants has made rapid strides through the labors of such men as Schleiden, Mohl, Naudin, Hofmeister, Strasburger, Baillon, Bornet, Decaisne, Tulasne, and last, but not least, Darwin.

The latter's work on cross fertilization not only opened up a wholly new field in connection with the subject of sexual physiology, but his works on climbing plants and on insectivorous plants, as well as his earlier work, in which he promulgated his doctrine of the origin of species by natural selection, have given a tremendous impulse to other branches of vegetable physiology.

It is true that this development of which we have just been speaking has mainly been on the purely scientific rather than on the utilitarian side, at least until quite recently. But a science pursued for its own sake, with a pure love of knowledge for its motive, and regardless of ulterior results, could not but lead to important practical applications, and so it has been in this instance. Especially have the developments in vegetable physiology found abundant applications. There is no branch of economic botany that has not received tremendous impetus from the researches of such men as Sachs, Strasburger, and Darwin.

The researches of these men seem far enough from what is ordinarily called practical, nevertheless, they have served as a leaven, to leaven the whole lump of botany, practical as well as theoretical; and economic botany, which for a thousand years had stood still, now shows everywhere signs of the most stirring activity. Not only are the old departments of the subject revivified, but new ones have sprung into life. Agricultural experiment stations, in many cases most elaborately equipped for the investigation of all that relates to useful plants, have been established in every country in Europe, and in nearly every State in the Union; courses in forestry have been established in some of the European and I believe in at least one of our American universities; and various professional schools, particularly medical schools and schools of pharmacy, have felt the new impulse, and established laboratories where medicinal plants are investigated structurally, chemically, and with reference to their physiological action.

Let us glance now at the departments of economic botany. These may be stated to be as follows: (1) Agricultural botany; (2) horticultural botany, with its subdepartments of pomology, arboriculture, and floriculture; (3) forestry; and (4) medical or pharmaceutical botany.

This classification is in some respects one of convenience and custom rather than a strictly scientific one. It would be hard, for example, to draw a sharp line of demarkation between agricultural and horticultural botany.

Agricultural botany, using the term in its commonly accepted sense, includes all knowledge relating to the plants which are cultivated on the farm in distinction from those cultivated in gardens or orchards, and from those growing wild in field or forest. It includes the botany of the cereals, the fodder plants, the edible roots and tubers, various textile plants, and others whose products are widely used or cultivated on an extensive scale.

Under horticultural botany is usually included the botany of those plants which are cultivated in gardens and orchards, whether for food or other utilitarian purposes or merely for decorative uses, as in the cultivation of ornamental trees, shrubs, and flowers.

Pomology, more properly called fructiculture, is that department of it which relates to the culture of fruits; arboriculture, that branch which relates to the culture of ornamental trees; and floriculture, the branch which relates to the culture of flowers.

Horticulture is really a branch of agriculture, though custom and, to a certain extent, convenience maintain a distinction between them. Both are governed by the same general principles. In horticulture, however, the plant is more often subjected to artificial conditions, for example, to stove heat, root pruning, budding, grafting, layering, forcing, and so on.

The proper study of both includes in its scope the commercial history, systematic relationships, life histories, structure, physiology and pathology of the plants cultivated.

Of these, physiology takes the leading rank both in its importance and in its scope. It includes not only the study of plant foods and the modes of their assimilation, respiration, metabolism, reproduction, and the influence of various external agents and conditions, as light, heat, soil, drainage, etc., on plants in general, but the study of all these in reference to each particular variety or species under cultivation, and as subject to more or less artificial conditions. The kinds of soil and drainage best suited to the plant, the best manures to employ, the proper order of cropping to prevent exhaustion of the soil, these are things also which are not to be neglected. Of scarcely less importance is a knowledge of the facts and conditions of plant variation, the laws and methods of hybridization, and the modes of taking advantage of these for the improvement of plants in any desired direction. Nothing, in fact, that has happened recently has so stimulated the agricultural arts, or encouraged so much hope for future progress in them, as the revelations of the last twenty-five years in vegetable physiology.

The pathology of cultivated plants, that is, the nature of the bacterial and fungous diseases to which they are liable, and that of the insect pests that attack them, together with the knowledge we are acquiring slowly but surely of the best methods of dealing with these enemies, is of scarcely less practical importance. It is a subject also which at the present time is engaging the talents of many of our best botanical investigators.

Forestry is a comparatively new, though none the less thriving and important branch of economic botany. Besides including a knowledge of the structure, botanical relationships, physiology, and pathology of trees, it deals with such subjects as the best modes of planting, caring for and preserving forest growths, of reforesting denuded areas, of estimating by means of accurate tests the relative values of different timbers for constructive and other purposes, the rate of forest growth, the age attained by different species of trees, the relations of timbered areas to rainfall, to drainage, to the health of the population, and to the permanence of the configuration of the earth's surface, the methods of preventing the encroachment of sand dunes upon fertile areas, and the introduction and acclimatization of new species of trees.

In many of the older countries of Europe schools of forestry have been established and systematic measures are employed for the care and preservation of the forests. In Germany and France forestry has become a profession, which gives employment to a considerable number of intelligent men. In this country we have permitted the destruction of a very large share of our forest wealth—a wealth greater probably than that of any other nation in the world—and we are only now awaking to a sense of the loss and beginning to take measures to prevent further destruction.

Although the means thus far adopted are quite inadequate, they form an entering wedge to further action, and the splendid work that has been done by Sargent and Fernald has so awakened intelligent public sentiment that we may hope for satisfactory legislation on the subject in the near future.

Pharmaceutical or medical botany, the branch which most directly concerns us, is in some respects behind the other departments in its development; in others, however, it is fully abreast of them. Although general botany owes more to this branch than to any other, since the earlier botanists were mostly either physicians or pharmacists and since the earliest botanical gardens were established chiefly for the cultivation of medicinal plants, medical botany is behind the age in the cultivation and improvement of the plants with which it deals. There are still a very large number of important medicinal plants that are either not cultivated at all or are cultivated to such a limited extent that we are still dependent for our supplies of them on the primitive forests and prairies. Our agricultural colleges and experiment stations leave the medicinal plants almost wholly out of account, and, excepting the case of the cinchonas and a very few other drugs, experiments with them are left entirely to individual enterprise.

It is behind the agricultural branches also, in the fact that inadequate attention has been given to the study of the structure of the plants with which it deals. True, there are signs of awakening in this direction and a hope for better things in the near future.

As respects the physiology of medicinal plants and particularly that important branch of it which relates to the increase and improvement of the yield of medicinal constituents, nothing more encouraging may be said than that it is sadly neglected, the schools, even those of pharmacy, having ignored the subject altogether.

In two or three lines only does this department appear to have kept abreast of agricultural and horticultural botany. This is, perhaps, the case with vegetable histology, and it is decidedly the fact with the investigation of the chemical constituents of plants. Since the German apothecary, Serturner, in 1817, announced the discovery and isolation of the first known alkaloid, morphine, there has been in our profession increasing activity in this line of research, and never has there been such widespread interest in the subject as at present. To the credit of this college it should be said that it has done its full share of work of this character.

But what has been done—valuable as it is—is only an infinitesimal part of what remains to do. That may not be wholly true which Emerson suggests, that every weed is a plant the uses of which we do not yet understand, but it is safe enough to say that among the 175,000 or therabout of plant species that have been described and named, and the possibly as many more that await discovery, there are many times the number we know of at present that are capable of serving mankind in a useful way. We know not what value may lie even in many of the despised weeds about us, to be revealed by careful chemical research. Every day we are discovering new vegetable principles and discovering new uses for old ones. If such wealth as the aniline dyes came from such an unpromising and apparently worthless substance as coal tar, what may we not hope from the many thousands of plants that are scarcely known to us yet, except by name? Of the flowering plants that remain to be discovered, we cannot count on more than from 10,000 to 12,000 species, but these give great promise, because they lie mostly in the great central regions of Africa and Asia, where plants of much potency may be expected to occur.

The least explored botanical fields are those of fungi and bacteria. How many species of these groups remain to be described it is impossible even to guess. We can only say that the number is vast, and possibly when all are known may be found to exceed that of all other plants put together. The probabilities of obtaining many important remedial agents from each of these groups are most encouraging to investigators. Many of the fungi are proved to be palatable, highly nutritious and easily cultivated food plants, and it is largely suspicion and ignorance that prevents us from making more common use of them. The many poisonous species have made the whole group suspected, but this fact should encourage rather than retard pharmaceutical research, for dangerous poisons have often proved useful remedies.

As for bacteriology, so closely and directly is its study related to human welfare, and so important are its achievements in recent years, that it is well entitled to rank as a separate branch of economic botany. Its achievements in the score of years of its existence have been vast, but we may hope for much greater results in the future.

According to Sturtevant there are 1,192 species of plants that have at one time or other been cultivated for food, and the whole number which are known to have been used as food, including those resorted to in time of famine, is 4,000 species, but even the smaller of these includes many plants of little value. I find even in Smith's "Dictionary of Economic Plants" only 515 food plants mentioned, and this certainly would include all of the important kinds. Even of these I judge at least two-thirds have either a very doubtful value or only a local or very limited use. The great food staples of the world are really few in number, but there seems no good reason why they should not be increased many fold, not merely by discovery of new kinds, but by the improvement of old ones. If it is true, as some botanists believe, that wheat in its numerous varieties, now constituting probably the most important food of the human race, was originally derived from Ægilops ovata, a grass of little consequence in its wild state even as a forage plant, what possibilities are presented by numerous other grasses, if only they could be subjected to intelligent cultivation?

A man walking along the coast of England or France may to-day find a tall, straight stemmed, glaucous leaved crucifer, which bears at its apex a compact raceme of yellow flowers. Its leaves are lobed and somewhat wavy or crispate, and the stem, when stripped of them and dried, would make a fair walking stick. The plant is the wild Brassica oleraceæ, from which have been developed the common white cabbage, red cabbage, Savoys, coleworts, the borecole or Scotch kale, curly greens, cauliflower, broccoli, kohlrabi, the cow or Jersey cabbage, and as some believe the common turnip, forms in appearance and habit often so different from each other that no one not a botanist would suspect their common origin. Precisely how they originated we do not know; but they are the result of a long course of cultivation. Are there no other of our Cruciferæ that possess similar possibilities?

A few years ago there were enumerated in the transactions of one of the horticultural societies of Great Britain, 1,500 different varieties of the apple, and this probably does not include nearly all that have been produced from the original wild apple of Europe and Asia. Many other species of Pyrus that have never been subjected to experiment possess, for aught we know, as much promise as Pyrus malus.

The Japanese have made out of their persimmon what they regard as their most valuable cultivated fruit, but the wild plant, I am told, yields a fruit no more desirable than those of our two wild species. In fact, our common persimmon shows a great tendency to variation, even in the wild state, thus making it a most promising subject for experiment. Scarcely less urgently do the butternut, black walnut, hickories, hazels, blueberries, serviceberry, some of the Shepherdias, the species of Physalis, Apios tuberosa, Psoralia esculenta and many other native species, invite us to experiment.

Of course, experiments of this kind must be made by government and in long lines of policy, as important results in the case of long-lived plants at least could not be expected in a single generation of men. It is not necessary to suppose, however, that because it has taken thousands of years to bring about the present excellence of many of our food plants, it would take the same length of time to similarly improve our wild

ones. What was accomplished unintelligently in long ages might probably be done in a few generations by taking advantage of the now known laws of variation, hybridizing and artificial selection.

Coming again to medicinal plants, I find that the last edition of the United States Dispensatory enumerates over 1,300 that are more or less employed in medicine, and a fair estimate of the whole number in use, I think, would be not far from 3,000. This, of course, would not include all that have been employed in medicine; it would be impossible, even approximately, to estimate these; but only those plants that are at the present time more or less habitually employed by man, either civilized or savage. Of these, probably the great majority are worthless or nearly so for the purposes for which they are employed. Even of those mentioned in the Dispensatory, only 244 are regarded as of sufficient value to be given a place in the Pharmacopœia of 1890, and some of these, I am sure, are retained, not because of their intrinsic worth so much as because they are extensively used.

But taking the pharmacopœial plants as representing fairly well those at present approved by the intelligence of mankind, how small a proportion must it be of those that will ultimately be proved valuable! How small a portion of the earth's flora has been investigated even superficially, with reference either to medicinal constituents or physiological action! Even among the drugs that have been studied to some extent with reference to these points, in how few cases has the work been done in an exhaustive or thorough way! The greater the amount of study given to the chemical principles of plants, the more we realize how endless is the variety and how great the probabilities are that vast numbers of undiscovered ones yet exist that may prove of inestimable value to mankind.

In the line of cultivation of medicinal plants, with the view to their improvement, just enough has been done to prove the importance of further work in the same direction. Owing to the imminent danger that the destructive methods of gathering cinchona barks in South America would soon lead to the extermination of these trees, the necessity for cultivating them arose a few decades ago, and experiments were begun in India and elsewhere on a large scale, and with most interesting and suggestive results. It has been found that by careful selection of favorable species, by crossing and again selecting favorable variations, barks may be produced which yield double or even treble the quantity of alkaloids produced by the best varieties from the wild trees in their native Andes. Therefore, by precisely the methods employed by the floriculturist and pomologist, the drug gardener may improve the medicinal plants he cultivates.

Only one other line of development will I occupy a moment in directing attention to, and that is, the possibilities that lie in the micro-chemical study of drugs. The methods of macro-chemical investigation are under such headway that creditable work is being done by them in chemical laboratories the world over; but only quite recently have micro-chemical methods risen to prominence. It is now possible, by means of the microscope, to recognize with certainty the presence of a large number of important medicinal constituents, including many of the alkaloids and glucosides. In many cases, to one skilled in the use of the microscope, it constitutes the simplest and speediest mode of analyzing a drug qualitatively. Among the glucosides that are recognizable by this means are coniferin, datiscin, frangulin, hesperidin, phloridzin, rutin, salicin and saponin; and among the alkaloids, aconitine, atropine, berberine, brucine, colchicine, corydaline, cytisine, morphine, narcotine, narceine, piperine, strychnine, theobromine, caffeine, veratrine, and nicotine.

The microscope, in the hands of the intelligent pharmacist, is thus destined to become a much more important instrument than heretofore in identifying drugs, judging of their quality and detecting adulterations. —*American Journal of Pharmacy.*

LIFE ON LAKE TITICACA.

By SOLON I. BAILEY.

LAKE Titicaca rests in the elevated plateau between the eastern and western ranges of the Andes.

The mean elevation of its surface is 12,505 feet above the level of the sea, or about twice that of the summit of Mt. Washington, White Mountains.

It lies northwest and southeast. Its greatest length and width are about 120 and 50 miles respectively. It holds the well known distinction of being the loftiest lake in the world upon which any considerable navigation is carried on. At present two small steamboats make regular trips on the lake between Puno, in Peru, and Chililaya, in Bolivia.

This steamboat service supplements the railway system from Mollendo to Puno, and together with a well equipped stage line from Chililaya, completes the connection between the Pacific and La Paz. The present terminus of the railway is Puno. Neither this nor any other line of railway reaches La Paz, as has been incorrectly affirmed by some American publications. The distance from Mollendo to Arequipa is 107 miles, and from the latter city to Puno 218 miles, in all 325 miles from the ocean to the lake. Between Arequipa and Puno the road crosses the crest of the Cordillera, or Western Andes, reaching, at Crucero Alto, the elevation of 14,666 feet, making it without doubt the loftiest railway in actual operation in South America.

From Puno across the lake to Chililaya is 104 miles, and 36 miles thence by stage to La Paz.

From Juliaca, on the Puno division of the above railways, is a branch road extending northwest. This is known as the Cuzco division, but at present it only reaches Santa Rosa, a distance of 82 miles from Juliaca and less than one-third the distance to Cuzco.

The ancient capital of the Incas has not yet been disturbed by the whistle of the locomotive, but it is proposed to extend the main line around the southern shore of the lake to La Paz, and the branch to Cuzco.

The two small steamboats, of some 60 tons burden, now running on the lake, were built in England as gunboats for the Peruvian government. Before the construction of the railway, they were brought in sections on the backs of men and animals from Arica, and set up on the shores of the lake. Not proving necessary as a protection against Bolivia, they were remodeled for merchant service and have made regular trips for some years. They are not fast boats, but speed is not necessary where the only competition is with Indian "balsas." The lake is very deep in many parts, but unfortunately near Puno and Chililaya it is quite shallow, especially in Puno Bay, requiring considerable dredging. The fuel used on these boats is unique in steamboat navigation. Coal is very expensive. To run each boat one hour requires 400 pounds of coal, costing $4. Llama dung is, however, collected in great quantities by the Indians and sold in sacks containing four bushels at 10 cents per sack. Eight sacks of dung run the boat one hour and cost but 80 cents, only one-fifth the expense of coal. The fire thus furnished is sufficiently hot, but is quite unsteady, and with much waste, causing the engineer and firemen some annoyance.

The same fuel is used in all this region for cooking. In this connection it may be of interest to state that on the locomotives that run between Mollendo and Puno is used a fuel called "yareta," a moss-like form of vegetation which grows in dense conical masses from one to two feet in diameter. It contains considerable resinous matter, and makes a hot fire. It grows on the lofty plateaus and mountains, is cheaper than coal, and is used in considerable quantities.

When the depth of the water will allow, two small steamers also ply on the river Desaguadero, as far as Nasacara. The river Desaguadero forms the only outlet for Lake Titicaca, and though it is a stream of considerable size, it is evident that more water flows into the lake than finds its way out by this channel. Owing to its great area and its position, no doubt a vast amount is lost by evaporation. In fact, the water, through apparently fresh in the deeper parts, has, near the shore, an alkaline taste.

The small steamboats mentioned do not comprise all the navigation that takes place on Lake Titicaca. Formerly they made trips around the lake to various small ports, picking up cargoes. Now the trade between Puna and Chililaya and the Desaguadero River takes all their time, and their place in other localities is in part taken by the Indian and his balsa. The balsa of Lake Titicaca is an interesting craft. It is constructed of the reeds that grow abundantly in the shallow places. These are bound together into huge bundles of the desired length. Two of these bundles fastened together and turned up at the ends, in canoe fashion, form the raft or balsa proper. Two smaller bundles form rude gunwales. A sail is made of the same materials, and by this and a long pole the Indian makes his way for considerable distances. Speed is not necessary, for he is in no hurry. These balsas have been used for many generations. A commentary on the Indian character is furnished by the following incident: When unable to use his sail, he must paddle his craft slowly and laboriously by means of his pole. A gentleman desiring to improve their condition, procured some oars with broad blades for their use, but these they refused, remarking that poles had served their fathers well and hence were good enough for them also. From the northern parts of the lake the Indians bring fruit and vegetables to Puno for sale.

From the islands of Taquëli and Soto are brought pebbles—from the former black or drab and from the latter white. They are used for the variegated pavements in the courts of the better houses. The Indians avoid, however, the more exposed portions of the lake, as violent storms occasionally sweep over it. At such times even the steamboats find it necessary to change their course, and passengers are especially liable to seasickness.

A Peruvian gentleman, for fourteen years a purser on Pacific steamships without a touch of seasickness, experienced a severe attack of this unpleasant malady during a storm on the lake. Not far from Puno is a little fishing town, the huts being built on the steep, rocky hillside and the balsas drawn up on the shore. The lake furnishes abundance of good fish, and the surface near shore swarms with a variety of water fowl. Several islands are inhabited. The largest is Titicaca, sacred in Peruvian annals, for on its bleak northern end is the spot where Manco Capac, divine messenger from his father, the sun, first stepped. He certainly chose a bleak and unpromising spot from whence to start on his beneficent mission.

On Titicaca and Coati, near by, are the ruins of various so called palaces of the later Incas and temples for the priests and virgins of the sun. The islands now belong to Bolivia, and for political reasons no one is allowed to land on them without special permission from the government. Among these monuments of the past live to day a few Indians, really but serfs in a land once ruled by their ancestors. On the southern end of Titicaca is a large sheltered bay, with pleasant hills sloping up from the shore, with cultivated fields and the huts of the natives. Both here, however, and on the plateaus surrounding the lake the climate is severe and the conditions of life hard, and furnish a good commentary on the genius of the Inca race. Corn will not ripen, or with the most extreme difficulty. The only cereals capable of cultivation are barley, quinoa, and canagua. The summer and rainy season is from November to March. During this time whatever agricultural labor is to be done must be accomplished. Even during this season sleet is not uncommon, and snow lies low on the surrounding mountains. By birth and experience inured to the rigors of such a climate, with bare legs and feet, the natives seem not much affected by the cold. Lake Titicaca never freezes over, yet ice forms near shore. In winter the temperature is often far below the freezing point. Yet the lake must tend to equalize the temperature. On the Bolivian side, at 5 P. M. of November 26, I found the temperature of the air 52° F. and that of the water 58°. At 7 A. M. the following morning, in the Gulf of Puno, the temperature of the air was 42° and of the water 57°. In the middle of the day no doubt the air is warmer than the lake. To the north of Titicaca, toward Cuzco, there are some populous towns, and the people are largely engaged in caring for the enormous herds of cattle of the great land owners.

For this labor each receives about $25 per year, besides which they are allowed some of the sterile land for cultivation. Their poverty can be judged by the fact, vouched for by a Peruvian gentleman of wealth and position, that although a whole sheep can be had for 40 cents, these Indians are too poor to eat meat.

Strong drinks have to a large extent taken the place of the comparatively harmless "chicha," adding to their misery. They live in little adobe houses, with earth floor and usually grass-thatched roof. To keep warm they have a small door, and for a window one little opening from four to six inches square. On the Bolivian plateau the condition of the Indian seems more favorable. Yet everywhere they appear fairly contented. They have no Yankee love of change; no dreams of political advancement haunt them. Seeing them, one can understand how they were content under the paternal despotism of the Incas. They are quiet, stupid, and superstitious. Yet they have not forgotten their origin. The very air in Peru is full of the past. Stories of the glories of the Incas, and of treasures buried and not yet found, are everywhere current and everywhere believed.

In a great cathedral I saw an Indian with rapt face worshiping before an image of the Christ. But the image was decked out in the full garb of an Inca. Even in his religion—and he is very religious—the Indian seems to be thinking of the past, when, instead of belonging to a servile race, people of his blood held sway over a country embracing the present limits of Ecuador, Peru, Bolivia, and Chile. Apparently he has lost much by the Spanish conquest. In contact with a higher civilization he has not held his own. A so-called Christian conquest accomplished the material, moral, and religious degeneration of the Indian of the Andes.

[NATURE.]

THE DETERMINATION OF LATITUDE AND LONGITUDE BY STELLAR PHOTOGRAPHY.

LATITUDE and longitude may be determined on shore with considerable accuracy by means of an ordinary photographic camera; and this method will, I think, prove useful for several reasons. The observation part of the business, which consists in taking the photographs, is separated from the measuring and calculating part, and may be performed by different persons at different times and places. For taking the photographs no scientific apparatus is wanted besides the camera and a watch, the latter to measure intervals of not more than a few hours with an accuracy of a second or so. Any one may easily be instructed to take the photographs, as no mathematics and very little astronomical knowledge are wanted, only the measuring of the plates and the calculation requiring some scientific training.

I will first describe the determination of latitude. The general plan is well known to astronomers; it is here only adapted to the use of an ordinary camera.

If the lens is directed to the zenith and the stars are allowed to draw their trails over the plate, it will evidently be possible to determine the latitude from the plate, provided the point of the plate is known which corresponds to the zenith. Now this point may be found in the following manner: Let the camera float and be turned while floating. It will turn exactly round a vertical axis. The zenith will then be the only point of the sky whose corresponding point on the plate will remain unaltered. The way I arranged the experiment was this: I placed the camera in a rectangular tin box, lens upward, fixing it firmly by wedges. The box was ballasted so as not to be capsized when floating. Photographic plates will do as ballast, but it is better to take a plate of lead, which brings the center of gravity lower down, and thereby increases the stability. I then filled a second rectangular box, somewhat larger than the first, with so much water that, when the first box floated in it, the rims of both boxes were in the same plane. Two opposite points on the rim of the inner box were fastened to the rim of the outer one, each with two strings, forming an obtuse angle. This prevented the inner box from turning during an exposure. The strings need not be tight, as the forces they have to resist are small.

Having placed the whole apparatus on a firm table in the garden, I removed the cap from the lens. As the trails of brighter stars may generally be measured more accurately than those of faint ones, I exposed long enough for a star of the third magnitude to pass sufficiently near the zenith to appear on the plate. After replacing the cap, I turned the whole apparatus carefully through an angle of 180°. For this purpose I had pressed a row of flat nails into the board along one edge of the outer box, and having turned it, I let the same edge of the box touch the row of nails from the other side. Before again removing the cap, I waited about three minutes to allow the oscillations of the water and the inner box to subside. The second exposure I made long enough for the image of a star of about the third magnitude to be thrown on the plate during the star's culmination near the trail of the star of the first exposure. In order to see that it is possible to determine the latitude from this plate, imagine first the trails of the two stars to touch. That would be a proof that they had passed the meridian on different sides, but at the same distance from the zenith. The mean of their declinations, taken from the almanacs, would, therefore, be equal to the distance of the zenith from the equator that is equal to the geographical latitude. If, on the other hand, the trails of the two stars do not touch, their shortest distance may be measured.

Now the distance of the trails of any other two stars, which appear during the same exposure, will, when their declinations are taken from the almanacs, enable us to calculate what angle approximately corresponds to a certain length, the approximation being close for small lengths. Thus we are enabled to calculate what the declination of the second star would have been, if its trail had touched the trail of the first star, and thus the latitude may be found.

Generally there will be the trails of several stars in both exposures available, so that one plate will allow of several determinations, and thereby of an elimination of errors. The results of seven plates, taken on

different nights in my garden in Hanover, Germany, will give an idea of the accuracy.

52°	22·36
52°	22·56
52°	22·47
52°	22·78
52°	22·10
52°	22·93
52°	22·90
Mean: 52°	22·72 (mean error of a single plate = 0·2).

According to the *Preussische Landesaufnahme* the latitude should be

52° 22·84

The same plate may also serve to determine the deviation of a watch from local mean time, if the time of the watch is noted each time the cap is withdrawn and replaced. Imagine, first, that a star was photographed whose declination coincided with the geographical latitude, and imagine that the box could be turned infinitely quickly, without any oscillations being started. If we then found that the two trails of the star corresponding to the two exposures touched each other at one end, the end corresponding to the moment the box was turned, we might conclude that the star at this moment was in the zenith, for there alone the image of the star would remain unaffected by the turning of the plate. Now, we can calculate from the almanac the local mean time of the moment when this particular star culminates, and this would give us the deviation of our watch from local mean time. Imagine, now, the box had not been turned at the moment the star culminated, but, say, ten minutes later. Then the two trails would not have one end in common. The ends corresponding to the moment when the box was turned would be on opposite sides of the zenith, at the same distance from it. Now we should be able, by the length of the trails, to determine what interval of time corresponds to a given length, and so the plate would show us that the culmination of the star took place ten minutes before the box was turned. If the box is not turned very quickly, the interval after replacing and before removing the cap must be taken into account. But it is evident that we can calculate where the ends of the trails would have been if the box had been turned infinitely quickly. If there is no star that passes exactly through the zenith, we must take one that passes near the zenith. This will also do. By the ends of the trails we find which point of the plate corresponds to the zenith, and at the same time we can, by the trails and their ends, find out the line representing the meridian. This gives us the necessary data for finding the deviation of our watch from local mean time. For a star near to the zenith a small error in the direction of the meridian will make very little difference. I have spoken of the ends of the trails as a means of determining local mean time only for the sake of simplicity. It is far preferable to proceed differently, and to interrupt the first and the second exposure a number of times, thus causing as many interruptions of each trail. Five seconds or less will do very well for the length of an interruption. These interruptions are preferable to the ends, because they are symmetrical, and their middle can with more accuracy be brought under the cross hairs of a micrometer. My lens having a focus of about 24 cm. made one minute about equal to 0·6 mm. on the trails of stars that culminate near the zenith. With a micrometer it is not difficult to measure exact within 0·01 mm., which is equivalent to one second of time.

If by the help of a chronometer Greenwich mean time were known at the place where the photograph was taken, the longitude would thus also be determined. But a chronometer can be dispensed with if another photograph is taken of the moon and the stars For this purpose the camera is taken out of its box, directed to the moon, and fixed as firmly as possible. A number of instantaneous photographs of the lunar disk are then taken, all on the same plate, at intervals of not less than two minutes, to prevent the images from overlapping. The camera must be touched as little and as gently as possible, so that it may remain in the same position. After a number of exposures, say six or eight, the camera is shut until the moon has quite gone out of the field. The cap is then again removed and the stars draw their trails over the plate, interrupted here and there, the lens being now and then covered for five seconds. If the local mean time of the instantaneous exposures of the lunar disk and of all the interruptions is known, the Greenwich mean time may be found from the plate. One may apply three different methods. Either one can determine the right ascension of the moon or the declination, or one can measure lunar distances. I have tried all three, and prefer the second, provided the moon is not near the maximum or minimum of her declination. For the slower rate of change of declination is made up by the greater accuracy with which it can be measured, on account of the trails being lines of constant declination. Each image of the lunar disk allows a separate determination, so that the final value is the mean of a number of determinations. (For the details of measuring, see my article in the *Zeitschrift fur Vermessungswesen*, August, 1893.)

The results of one plate for the difference of Greenwich mean time and local mean time were by the three methods

39·1	minutes.
39·1	"
38·6	"
Mean 38·93	"

while the true value is 38·943. This very close coincidence must be considered accidental. But I think one can well rely on the determination from one plate not differing more than 0·2 minute from the real value. When exposing for a longer time, the dew will sometimes condense on the lens, and render it opaque. To prevent this, I place a screen before the lens with a hole in it a little larger than the lens. The screen keeps the lens from cooling below the temperature of the surrounding air, and thus removes the cause for the condensation of dew. When determining the latitude the screen was arranged as a lid of the outer box, and served at the same time to protect the camera from gusts of wind. C. RUNGE.

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[FROM NATURE.]

AUGUST KUNDT.

PHYSICAL science, which within the lapse of six years has witnessed the death of Kirchhoff, Clausius and Hertz, has suffered another severe loss. On May 21, August Kundt, who was but fifty-four years of age, suddenly died at his country place near Lubeck.

Kundt was born at Schwerin, on November 18, 1839, and began his studies at Leipzig in 1860 under Hankel, Neumann, Bruhns and others. Thence he went to Berlin, where Encke, Forster, Dove and Kummer were his principal teachers. He began by giving special attention to astronomy, and, indeed, intended to devote himself to that branch of science. While yet undecided, however, he entered the private physical laboratory that Gustav Magnus had fitted out in the Prussian capital, and in which students with a decided taste for experimental investigation were allowed to work. From the beginning he displayed extraordinary experimental ability, combined with rare energy in the pursuit of the work he had once taken in hand, qualities which were characteristic of him during his whole scientific career. He also attended the physical "colloquia," which Magnus had introduced, and under the influence of the latter was definitely enrolled in the lists of experimental physicists.

He graduated at Berlin in April, 1864, with an investigation on the depolarization of light. The first and last of the theses appended to his dissertation (dedicated to Magnus) are characteristic of the state of his mind at that time. They run as follows:

(1) Vires animæ non minus metiri possumus, quam vires physicas.

(4) Theoriam a Cl. Fresnel de torsione planitiei polarisationis promulgatam si adoptamus, omnia ea corpora quæ planitiem polarisationis torquent, sub aptis conditionibus birefractionem demonstraturn esse, negare non possumus.

He never himself followed up the psychological lines of research hinted at in the first thesis; the last proposition is known to be entirely borne out by modern research on circular double refraction.

In 1867 he became "Privatdocent" in the University of Berlin, but was appointed to a professorship in the Swiss federal polytechnic school at Zurich in the following year. There he remained but two years, removing to Wurzburg in 1870, where his stay was of no longer duration, the then newly organized University of Strasburg having called him to represent his science on a brilliant staff of young and enterprising men, who within a few years brought their "alma mater" to a high level of excellence. In this work of organization Kundt was one of the most actively engaged, holding the office of rector in the year 1877, when but 38 years of age. Quite apart from his purely scientific reputation, this alone is sufficient to mark his name with golden letters in the annals of Strasburg University, for which he also erected an imperishable monument, the Physical Institute, well known throughout the scientific world as one of the best laboratories existing.

In 1888, when Prof. Von Helmholtz became president of the "Reichsanstalt," Kundt succeeded him as professor of experimental physics, and director of the Berlin Physical Institute. A prolonged period of scientific activity from a man of but fifty years of age with a world-wide reputation might still have been expected; but these hopes have proved vain. A few years ago the symptoms of a disease began to appear, which could not be subdued. Kundt fought for life to the last; and notwithstanding the slow but unceasing strides his ailment made, which would have entirely prostrated most other men, he continued his lectures and other pressing duties during the whole of last winter, thus setting an example of sacrifice to the cause of science even in the face of death. When, at the urgent instance of his medical advisers and friends, he stopped work and left Berlin, it proved of no avail; in fact, he may be said to have died as he had lived, in the midst of scientific work.

As an investigator Kundt was many sided; his discoveries are so generally known, that it is hardly necessary to describe them in detail. He first turned his attention to acoustics; his start in scientific life being the invention of the well known "Kundt's sound tubes," or "Kundt's dust figures," which he himself and others turned to account in many different ways. The application of that purely acoustic method led to the determination of the ratio of specific heats of mercury vapor. In collaboration with Warburg (1884), Kundt found this to be 5/3, as predicted by the kinetic theory for a monatomic gas. He also conducted researches on thermal conductivity and inter-diffusion of gases or vapors and on the influence of pressure on the surface tension of liquids; and developed his well known red and yellow dust spray method for investigating the pyro-electric and piezo-electric properties of crystals.

But in glancing over his life work as it now lies before us, it appears as if the palm ought to be assigned to his optical and magneto-optic discoveries. He began with a brilliant series of papers on anomalous dispersion, which placed this important subject on a sound footing. He described the doubly refractive properties of vibrating solids, of metallic films obtained by disintegration of cathodes and of certain liquids in motion, and investigated the optical properties of electrified quartz. With Rontgen he was at le to show a slight magneto-optic rotation in several vapors and compressed gases, which even Faraday had not been able to detect, and, on the other hand, its enormous value in iron, cobalt, and nickel. The latter will be known to coming generations as "Kundt's phenomenon." Last, but not least, he succeeded in determining the refractive indices of metals, which he was able to obtain in the shape of extremely thin prisms.

His experimental work, of which the above gives but an incomplete summary, is throughout characterized by the greatest ingenuity in the selection of means to attain definite ends, by the rare quality of ever-watchful self-criticism, which prevented his running away with himself. He possessed that instinctive and immediate power of discriminating the broad way of progress into the unknown from the stray paths leading into tangled wilderness, a faculty which he used to call the pioneering scent of the experimenter.

Space forbids an adequate account of what Kundt personally was to his family, his friends, and his pupils. The latter, a great number of whom are scattered throughout the civilized world, were attached to him by the strongest ties of a scientific and private character, and lost no chance of showing the high esteem they felt for him. They owe a life-long debt of gratitude to the great experimenter, who to most of them was not only a teacher, but also a personal friend, ever ready to render help and advice based on his varied experience of scientific life. H. DU BOIS.

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